



Ministry of
Northern Development
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Ontario

Aggregate Resources Inventory of the Towns of Bracebridge and Gravenhurst Southern Ontario

Ontario Geological Survey
Aggregate Resources Inventory
Paper 147

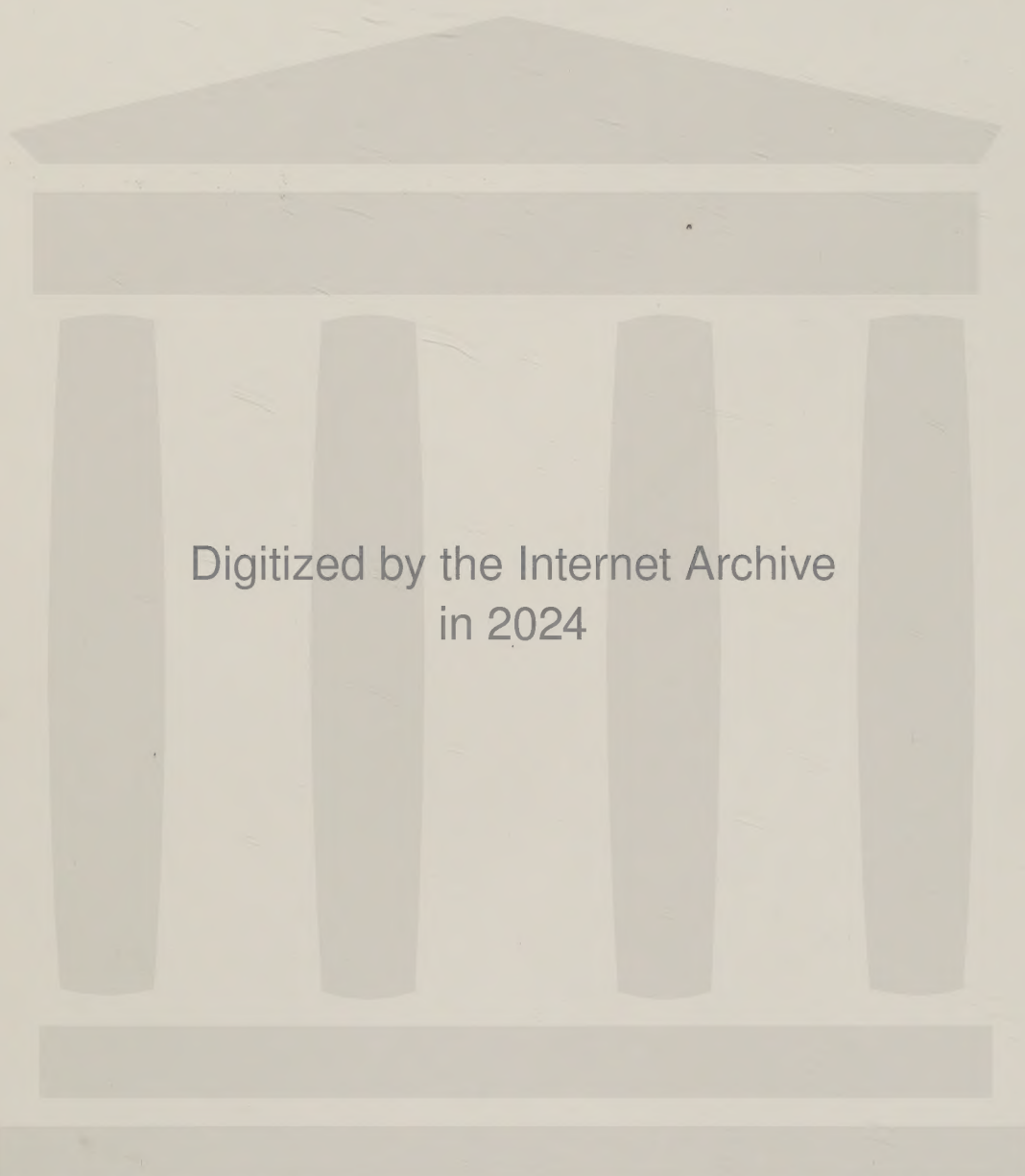
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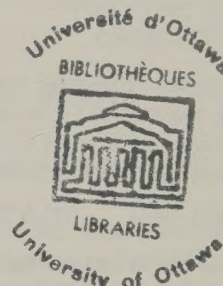


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**Ontario Geological Survey
Aggregate Resources Inventory
Paper 147**



**By Staff of the Engineering and Terrain Geology Section,
Ontario Geological Survey, Ministry of Northern Development and
Mines**

1990



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CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	Multiplied by	Gives	Imperial Unit	Multiplied by	Gives
LENGTH					
1 mm	0.039 37	inches	1 inch	25.4	mm
1 cm	0.393 70	inches	1 inch	2.54	cm
1 m	3.280 84	feet	1 foot	0.304 8	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	1.609 344	km
AREA					
1 cm ²	0.155 0	square inches	1 square inch	6.451 6	cm ²
1 m ²	10.763 9	square feet	1 square foot	0.092 903 04	m ²
1 km ²	0.386 10	square miles	1 square mile	2.589 988	km ²
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
VOLUME					
1 cm ³	0.061 02	cubic inches	1 cubic inch	16.387 064	cm ³
1 m ³	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m ³
1 m ³	1.308 0	cubic yards	1 cubic yard	0.764 555	m ³
CAPACITY					
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	4.546 090	L
MASS					
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	31.103 476 8	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	0.453 592 37	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	907.184 74	kg
1 t	1.102 311	tons (short)	1 ton (short)	0.907 184 74	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	1016.046 908 8	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	1.016 046 908 8	t
CONCENTRATION					
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.

Aggregate Resources Inventory of the Towns of Bracebridge and Gravenhurst Southern Ontario

By Staff¹ of the Engineering and Terrain Geology Section

1. Project Supervisor: I. Szoke; field work and report by: R.G. Gorman and A.M.D. Perigo; compilation and drafting by Staff of the Aggregate Assessment Office. Assistance with review provided by the Resident Geologist of the Algonquin District of the Ministry of Northern Development and Mines. The Mineral Resources Staff of Bracebridge District Office of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

Manuscript accepted for publication by Chief, Engineering and Terrain Geology Section, November 13, 1989. This report is published with the permission of V.G. Milne, Director, Ontario Geological Survey.

Abstract



Figure 1. Key map showing location of the towns of Bracebridge and Gravenhurst, scale 1:1584000.

This report includes an inventory and evaluation of sand and gravel resources as well as a discussion of bedrock aggregate potential for the towns of Bracebridge and Gravenhurst within the District Municipality of Muskoka. The report is based on previous studies in the area and a detailed field assessment undertaken in the summer of 1988. The investigation was conducted to delineate sand and gravel deposits and determine the quality and quantity of aggregate within the project area to help ensure sufficient aggregate resources are available for future use.

In the project area, 14 areas containing significant amounts of sand and gravel have been selected for possible resource protection at the primary level of significance. They consist largely of outwash, glaciolacustrine delta, subaqueous fan, ice-contact-delta and esker deposits. Selected Sand and Gravel Resource Areas occupy approximately 2800 acres (1130 ha). An estimated 1630 acres (660 ha) are currently available for extraction, containing resources of approximately 72.6 million tons (65.9 million tonnes). In addition, numerous deposits which add considerably to the resource base of the project area have been classified as resources of secondary significance.

Selected Resource Areas are not meant to be permanent, single land use units. They represent areas in which a major resource is known to exist and may be reserved wholly or partially for extractive development and/or resource protection.

In general, the project area is considered to contain large resources of sandy aggregate and limited resources of crushable gravel. Resources of crushable gravel are especially restricted in the geographic townships of Wood, Monck and Draper. The most significant potential sources of crushable gravel include outwash, subaqueous fan, deltaic and ice-contact-deltaic features located in the geographic townships of Macauley, McLean, Muskoka and Morrison.

The aggregate in the project area is considered hard and durable and is generally suitable for most usual applications. However, use of the material in hot-laid asphalt may be restricted in places by the presence of brittle and friable gneiss fragments within the gravel. In addition, the Ontario Ministry of Transportation will not accept local gravel for use in portland cement concrete which will be exposed to de-icing salts because there is a bonding problem between the aggregate and cement which results in concrete deterioration. Consequently, crushed limestone aggregate is imported into the project area from northern Simcoe County to meet demands for high specification aggregates.

The project area is underlain by Precambrian bedrock of the Canadian Shield. Recrystallized and deformed gneisses are the most widespread rock type. The bedrock in the project area exhibits wide variations with respect to aggregate quality over relatively short distances. Consequently, site specific testing is recommended prior to extraction.

Résumé

Ce rapport comprend un inventaire et une évaluation des ressources en sable et gravier. Il examine également le potentiel en agrégat dérivé du substratum rocheux des villes de Bracebridge et Gravenhurst dans le district municipal de Muskoka. Le rapport est basé sur des études antérieures faites dans la région et une évaluation détaillée effectuée sur le terrain pendant l'été 1988. Cette étude a été faite pour définir les dépôts de sable et de gravier et déterminer la qualité et la quantité des agrégats dans la région étudiée afin de s'assurer que les ressources en agrégats sont disponibles en quantité suffisante pour un usage futur.

Dans la région étudiée, 14 secteurs contenant des quantités importantes de sable et gravier ont été sélectionnés pour une possible protection des ressources de première importance. Ces secteurs contiennent essentiellement des dépôts d'épandage fluvio-glaciaire, de delta glaciolacustre, de cône de déjection subaquatique, de delta de contact glaciaire et d'eskers. Les secteurs riches en sable et en graviers sélectionnés occupent environ 2800 acres (1130 ha). Environ 1630 acres (660 ha) contenant approximativement 72.6 millions de tonnes (65.9 millions de tonnes métriques) de matériau, sont actuellement disponibles pour extraction. De plus, de nombreux dépôts, augmentant considérablement la base des ressources de la région étudiée, ont été classés comme ressources de seconde importance.

Les zones de ressources sélectionnées ne représentent pas des lots à usage unique et permanent. Ces zones représentent des surfaces dans lesquelles une ressource a été identifiée et pourrait être réservée entièrement ou partiellement pour développement à des fins d'extraction et/ou conservée pour la protection des ressources.

En général, le terrain étudié est supposé contenir de grandes quantités d'agrégats sableux et des quantités moindres de gravier concassable. Des ressources limitées en gravier concassable se trouvent dans les cantons géographiques de Wood, Monck et Draper. Les plus importantes sources de gravier concassable sont les dépôts d'épandage fluvio-glaciaire, de cônes de déjection subaquatique et les dépôts deltaïques de contact glaciaire situés dans les cantons géographiques de Macauley, McLean, Muskoka et Morrison.

L'agrégat dans la zone étudiée est considéré comme étant dur et durable et il se prête bien à la plupart des usages. Cependant l'utilisation de ce matériau avec l'asphalte à chaud peut présenter des problèmes de par la présence dans le gravier de fragments de gneiss qui sont friables. Il faut ajouter que le ministère des Transports de l'Ontario n'acceptera pas du gravier de source locale pour être incorporé dans le béton fait de ciment portland si celui-ci est destiné à être exposé aux sels de route, ceci en raison des problèmes de liage entre l'agrégat et le ciment ce qui entraînera la détérioration du béton. En conséquence, pour répondre à la demande en agrégats de haute qualité, du calcaire concassé est importé de la partie nord du comté de Simcoe.

La zone étudiée repose sur un socle précambrien qui appartient au Bouclier canadien. Des gneiss recrystallisés et déformés sont les roches les plus répandues. Le socle de la zone étudiée présente des grandes variations vis à vis de la qualité des agrégats sur des distances relativement courtes. Par conséquent, des essais préalables in situ sont recommandés avant l'exploitation.

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Introduction

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1987, the total tonnage of mineral aggregates extracted was 156 million tons (142 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Northern Development and Mines 1989).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of

available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of the resources.

The report includes an assessment of sand and gravel resources as well as a discussion on the potential for bedrock-derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

Part I — Inventory Methods

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References) as well as field examination of potential resource areas. Field methods include the examination of natural and man-made exposures of granular material. Most observations are made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation, the Ontario Geological Survey, and Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites include estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations are also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, subsurface materials may be assessed by hand augering and test pitting, supplemented by test hole drilling or excavation, and geophysical surveys using hammer seismic equipment. The symbols for and locations of sample sites, test hole sites, and geophysical traverse lines are noted on Maps 1A and 1B.

Deposits with potential for further extractive development or those where existing data are scarce, are studied in greater detail. Representative sections in these deposits are sampled in 25- to 100-pound (11 to 45 kg) units from existing pit faces or from test pits. The samples are analyzed for grain size distribution, and in some cases the Los Angeles abrasion and impact test, absorption, and Magnesium Sulphate soundness tests and petrographic analyses are carried out. Analyses are performed either in the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation, or in the Geoscience Laboratory, Ontario Geological Survey.

The field data are supplemented by pit information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation. Data contained in these files include field estimates of the depth, composition and “workability” of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The locations of additional sources were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Aerial photographs at various scales are used to determine the continuity of deposits, especially in areas where information is limited. Water well records, held by the Ontario Ministry of the Environment, are used in

some areas to corroborate deposit thickness estimates or to indicate the presence of buried granular material. These records are used in conjunction with other evidence.

Topographic maps of the National Topographic System, at a scale of 1:50 000, are used as a compilation base for the field and office data. The information is then transferred to a base map, also at a scale of 1:50 000. These base maps are prepared by the Surveys, Mapping and Remote Sensing Branch, Ontario Ministry of Natural Resources with information taken from maps of the National Topographic System by permission of Energy, Mines and Resources Canada, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been established, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kilograms per cubic metre).

$$\text{Tonnage} = \text{Area} \times \text{Thickness} \times \text{Density Factor}$$

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e., original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable because of the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g., wayside and abandoned pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage

(Column 7) presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however the aggregate potential of these deposits is discussed in the report.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in

the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel deposits are termed possible resources (see Glossary, Appendix B) in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976).

Part II — Data Presentation and Interpretation

For each map area there are two maps, each portraying a different aspect of the aggregate resources in the report area. Maps 1A and 1B, “Distribution of Sand and Gravel Deposits”, give a comprehensive inventory of the sand and gravel resources in the report area. Maps 2A and 2B, “Selected Sand and Gravel Resource Areas”, show those deposits which are considered to represent the largest and/or highest quality resources in the area.

MAPS 1A AND 1B: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

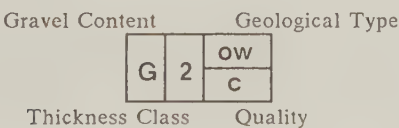
Maps 1A and 1B are derived from existing surficial geology maps of the area or from aerial photograph interpretation in areas where surficial mapping is incomplete. The maps show the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

On the maps, gravel deposits are indicated by dark brown shading while sand deposits are shaded light brown. The present level of extractive activity is also indicated. Sand and gravel pits are identified by a numbered dot on Maps 1A and 1B and described in Table 2. Each description notes the location and estimated face height of the pit as well as the estimated percentage gravel it contains. Test hole locations appear on Maps 1A and 1B as a point symbol and are described in Table 4. Geophysics lines are shown on Maps 1A and 1B by a line symbol and are interpreted in Table 5.

Maps 1A and 1B also present a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the maps. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Maps 1A and 1B. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The “gravel content” and “thickness class” are basic criteria for distinguishing different deposits. The “gravel content” symbol is an upper case “S” or “G”. The “S” indicates that the deposit is generally “sandy” and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. “G” indicates that the deposit contains more than 35 percent gravel.

The “thickness class” indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Maps 1A and 1B.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution of material sampled during field study. These symbols are derived from the information plotted on the aggregate grading curves found in the report. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically in the Texture Symbol by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:



MAPS 2A AND 2B: SELECTED SAND AND GRAVEL RESOURCE AREAS

Maps 2A and 2B are interpretative maps derived from an evaluation of the deposits shown on Maps 1A and 1B. The deposits identified on Maps 2A and 2B are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. Each area of primary significance is given a deposit number and all such deposits are shown by dark red shading on Maps 2A and 2B.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units. They represent areas in which a major resource is known to exist, and may be reserved wholly or partially for extractive development and/or resource protection.

Deposits of secondary significance are indicated by light red shading on Maps 2A and 2B. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the “best” resources in the report area, they may contain large quantities of sand and gravel and should be considered part of the aggregate supply of the area.

Areas of tertiary significance are outlined on the map by a solid line but have no shading. They are not considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the project area. Generally, deposits in Class 1 [greater than 20 feet (6 m) thick], and containing more than 35 percent gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in areas with low total resources.

Aggregate Quality

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the deposit symbols on Maps 1A and 1B. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the quality indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of a deposit. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a “C” in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material [greater than 4 inches (10 cm) in diameter] may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an “O” in the quality portion of the Deposit Symbol.

Another indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an “L” in the quality component of the Deposit Symbol.

If the Deposit Symbol shows either “C”, “O”, or “L” or any combination of these indicators, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt is made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of both the Ontario Ministry of Transportation (MTO) and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Quality data may also appear in Table 6, where the results of MTO quality tests are listed by test type and sample location. The types of tests conducted and the test specifications are explained in Appendixes B and D, respectively.

Analyses of unprocessed samples obtained from test holes, pits or sample sites are plotted on grain size distribution graphs. On the graphs are the Ontario Ministry of Transportation’s gradation specification envelopes for aggregate products: Granular Base Course A, B and C; Hot-Laid Asphaltic Sand Nos. 1,2,3,4, and 8; and concrete sand. By plotting the gradation curves with respect to the specification envelopes, it can be deter-

mined how well the unprocessed sampled material meets the criteria for each product. These graphs, called Aggregate Grading Curves, follow the tables in the report.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production

trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a project area should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, an area that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Areas with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

BEDROCK RESOURCES

The Precambrian shield rocks in northern Ontario are generally more complex and variable than the Paleozoic rocks of southern Ontario. They often show wide variations in mineralogy, texture (grain size), joint patterns and degree of weathering, even within specific rock types and over relatively short distances. As these factors are considered important in determining the suitability of the bedrock for use as aggregate, the aggregate potential may also vary considerably from location to location.

Careful selection is especially important if the bedrock is to be used as concrete aggregate. Deleterious chemical reactions may develop in the concrete which can lead to its eventual deterioration. Fortunately, these chemical reactions should not influence the use of bedrock-derived aggregate for such uses as road-base material. However, highly weathered, very porous and friable rock should be avoided for all uses.

For these reasons, no specific bedrock resources have been selected for resource protection. A summary of the bedrock resources on a regional level is included in the Bedrock Geology and Resource Potential section.

Part III — Assessment of Aggregate Resources in the Towns of Bracebridge and Gravenhurst

LOCATION AND POPULATION

The report area includes the towns of Bracebridge and Gravenhurst within the District Municipality of Muskoka. The towns occupy 273 941 acres (110 864 ha) and were incorporated in 1971. The main population centres in the report area are the former towns of Bracebridge and Gravenhurst. Smaller communities in the report area include Kashe Lake, Severn Bridge, Kilworthy, Uffington, Barkway, Vankoughnet and Muskoka Falls. The area is covered by the Penetanguishene (31 D/13), Gravenhurst (31 D/14), Minden (31 D/15), Haliburton (31 E/2) and Bracebridge (31 E/3) map sheets of the National Topographic System, at a scale of 1:50 000.

For the purposes of this report, the project area has been subdivided into two separate map areas. The town of Bracebridge encompasses the geographic townships of Macaulay, Oakley and Draper, and parts of the geographic townships of Monck, Muskoka and McLean. The town of Gravenhurst consists of the geographic townships of Morrison and Ryde and parts of the geographic townships of Wood and Muskoka.

The population of the report area in 1985 was 17 743, an increase of approximately five percent since 1980 (Ontario Ministry of Intergovernmental Affairs 1981; Ontario Ministry of Municipal Affairs 1988). The number of households has increased as well. In 1985, there were 11 905 households, and there were roughly 1.5 persons per household (Ontario Ministry of Municipal Affairs 1987). This is an increase in households of approximately 5.5 percent over the 1981 value (Ontario Ministry of Municipal Affairs and Housing 1983). The relatively high ratio of households to population probably reflects the number of cottages or seasonal dwellings, as the household value is more loosely defined than is the population, and has likely included a few cottages (Ontario Ministry of Municipal Affairs 1988).

Primary employers within the report area are the lumber and tourism industries (Chapman 1975; Chapman and Putnam 1984). The natural scenic beauty of the study area and its close proximity to large urban population centres in the south make the area ideal for recreation. Cottages line the shores of most major lakes and rivers in the Muskoka area and may be used year-round for hunting and winter activities such as skiing and snowmobiling (Chapman 1975).

There are several features which help to attract people north to the Muskoka area. A canoe route located along the South Branch Muskoka River incorporates 11 portages over approximately 26 miles (42 km) of watercourse. Bigwind Lake Provincial Park occupies approximately 5100 acres (2060 ha) in the geographic township of Oakley and has been classified by the Ministry of Natural Resources as a natural environment park.

In the autumn, many people are attracted to the Muskoka area to view the changing colour of the leaves.

A steadily increasing population has exerted a strong demand for aggregate in the report area. The ongoing maintenance of King's highways, as well as construction and maintenance of cottage access roads, is partially responsible for the demand. In addition, many of the houses and developments within the area are located on aggregate deposits. These factors may act to restrict availability of aggregate in some areas. Future residential and related developments may further limit the availability of aggregates for road-building and general construction purposes.

The report area is located approximately 100 miles (160 km) north of Toronto and is linked to Toronto by King's Highway 11. King's highways 117, 118 and 169 are also important transportation routes. In addition, a network of district and township roads provide access to most of the area, although some cottages are still only accessible by boat. The area is served by a Canadian National Railways line that runs parallel to King's Highway 11 and connects the towns of Gravenhurst and Bracebridge to other destinations to the south and north. The Muskoka Airfield, the only commercial airfield in the area, provides another transport route to the area.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The glacial deposits in the report area are underlain by Precambrian bedrock, which often occurs at, or just below, the surface of the ground throughout much of the report area. The bedrock in the area exhibits the typical "rock knob" or "rock ridge" topography of the Canadian Shield (Chapman and Putnam 1984; Mollard 1980b). The ridges and knobs are typically veneered by only very shallow soil or are bare. Large tracts of bare bedrock are especially common in the town of Gravenhurst. Glacial and postglacial materials make up the remainder of the land surface.

The glacial and postglacial deposits and the underlying bedrock combine to form three physiographic regions within the report area (Chapman and Putnam 1984). Most of the area is included within the Algonquin highlands and Georgian Bay fringe regions which are dominated by bedrock terrain. The Algonquin highlands region occurs in the north and is a region where bedrock knobs and ridges are interspersed with areas of varying thickness of till or other glacial deposits. A thin veneer of soil and exposed bedrock is characteristic of the Georgian Bay fringe which occurs in the southern part of the area. A strip of sand, silt and clay deposits occupy hollows between bedrock ridges along King's Highway 11. This region is known as the Number 11 strip.

Glacial deposits in the study area are related to the last major advance and melting back of a continental ice sheet during the Late Wisconsinan Substage of the Pleistocene Epoch (informally known as the "Great Ice Age"). During this substage, a discontinuous cover of till was deposited within the project area by glacial ice which advanced in a south-southwesterly direction (Sharpe 1978; Kaszycki, in preparation a, in preparation b). Exposures of this loose, stony, silty sand till are generally scarce. Where found, the till exists as a thin veneer over bedrock. Till is usually not well suited for aggregate use because it often contains excess fines and abundant oversize clasts. Till may, however, be a suitable source of fill in some localities.

Several deposits of undifferentiated ice-contact stratified drift were deposited close to the ice front as it melted northward. The origin of these complex features can be attributed to a variety of depositional environments and their appearance is marked by hummocky topography. These features occur as isolated bodies scattered throughout the report area. Although they are generally small, several of the deposits are considered important local sources of aggregate. The material exposed in these hummocky deposits varies from silty sand to coarse, crushable gravel.

The outwash features in the report area were deposited by meltwaters flowing into bedrock controlled valleys or basins beyond the ice margin. Major outwash deposits are situated in valleys presently occupied by the North Branch Muskoka River, South Branch Muskoka River, Gartersnake Creek and Black River, and alongside King's Highway 11 (Sharpe 1978; Staff of the Algonquin Region 1983). The outwash largely consists of well-stratified and uniformly bedded sandy aggregate. Fine to coarse gravel may be concentrated near the surface in many deposits. Outwash features are the most widespread aggregate deposits in the area and many of these deposits have been traditional aggregate sources.

As the ice front melted back, lower lying areas were inundated by waters of glacial Lake Algonquin (Sharpe 1978). These areas include the Number 11 strip region in which glaciolacustrine sedimentation has been widespread. Where meltwaters entered the lake directly from tunnels under the ice, subaqueous fans were formed (Rust and Romanelli 1975). Extensive subaqueous fan deposits, located along King's Highway 11 in the geographic township of Morrison, are major sources of aggregate in the town of Gravenhurst. The subaqueous fans either occur as isolated lobe- or fan-shaped features or larger, near-continuous sedimentary bodies formed by the joining together of several fans. These sedimentary bodies are often situated within or adjacent to the edges of south- to south-west-trending bedrock structural features which exerted strong control on deposition. Typically, these fans consist of silty fine to coarse sand, but may also contain fine to coarse gravel units. The aggregate in these features tends to become finer near the surface and the fans may be capped by layers of silt and clay. Gravel,

where present in these features, is usually concentrated at depth.

Where glacial meltwaters entered the glacial lake from sources above the water level, glaciolacustrine deltas were formed. These deltas are relatively flat features with steep frontal slopes. They consist largely of well-stratified and uniformly bedded sand and gravel. The gravel is usually concentrated near the surface of the deposits and/or in pockets. Many of the deltas are situated near King's Highway 11 and have been traditional sources of aggregate.

In the deep waters of the glacial lake, silt and clay were deposited. These silts and clays have little value as aggregate, however, clay, from near the former town of Bracebridge, has been used in the drain tile and brick industry (Guillet 1967). Glaciolacustrine plain sediments consisting predominantly of silty fine sand were laid down in the shallower parts of the lake. These glaciolacustrine sands are generally too fine for most aggregate uses except fill. Broad plains of glaciolacustrine deposits occur throughout the Number 11 strip region and near the former town of Bracebridge.

Erosional activity has been minimal since the disappearance of the ice sheet and the lowering of lake waters to present-day levels. Organic deposits have been developed in depressions in the land surface, and alluvium has been laid down along the courses of creeks and rivers.

EXTRACTIVE ACTIVITY

Over 200 sand and gravel pits have been identified in the towns of Bracebridge and Gravenhurst. The pits are generally widely distributed, although they tend to be concentrated close to highways, district roads and population centres. During field investigations, the pits were observed to be at various stages of development. Many of the pits had been worked recently, but several sites had been inactive for a considerable period of time. A number of these pits were located in small deposits, in some cases too small to delineate on the maps, and were near depletion. Products available from pits in the report area include asphaltic aggregate, as well as granular base course aggregate. The sandy aggregate has been found to be suitable for such uses as road subbase, septic beds and fill.

In general, the report area contains large resources of sandy aggregate. Resources of crushable gravel, however, are restricted, especially in the geographic townships of Wood, Monck and Draper. In many parts of the project area, much of the crushable gravel has been depleted and sand now dominates. Consequently, crushed limestone aggregate is imported into the project area from northern Simcoe County to meet demands for high specification aggregates. Many cottage access roads are constructed using local sandy aggregate as subbase and imported crushed stone as surfacing. Many bridge structures are also constructed using imported calcareous aggregate.

SELECTED SAND AND GRAVEL RESOURCE AREAS

Maps 1A and 1B for the towns of Bracebridge and Gravenhurst, respectively, indicate the deposits which contain granular materials. These deposits occupy a total of approximately 19700 acres (8000 ha) and contain an original resource tonnage of 445 million tons (405 million tonnes). Many of the deposits have limited potential for extraction because of the restricted amount of available resources, poor quality of the material, and/or poor accessibility. Consequently, only the most significant resources have been suggested for possible resource protection. The aggregate resources in parts of the project area have been previously described by Mollard (1980a, 1980b) and Sharpe (1978).

Glaciofluvial outwash deposits are the most common and widely distributed deposits in the report area. The outwash material is generally well suited for extractive activity. The deposits consist predominantly of well-stratified and uniformly bedded sand and gravel and generally contain only minor amounts of fines. However, large quantities of fines were noted in some pit sections. Outwash sand and gravel deposits are represented by Selected Sand and Gravel Resource Areas 1, 3, 5, 6, 7, 8, 9, 12a, 12b, 14a, 14b, 14c and 14d.

The ice-contact features, including eskers, also contain valuable resources of sand and gravel. The esker in Resource Area 11 is a prominent ridge that generally rises 25 feet (8 m) above the surrounding terrain. Aggregate of ice-contact origin is often well suited for road-building and construction uses, but it may show wider variations in grain size than the aggregate found in outwash features. The occurrence of bedrock ridges in both outwash and ice-contact deposits is a common pit-workability problem that can hamper pit operations and the estimation of remaining resources.

Several glaciolacustrine features well situated with respect to local markets and the existing road network have been traditional aggregate sources in the area. Selected Sand and Gravel Resource Areas 13a, 13b and 13c are subaqueous fan deposits situated in the geographic township of Morrison. The aggregate available from the fans may exhibit wide variations in grain size distribution. Typically, the fans consist of fine to coarse sand, but may also contain fine to coarse gravel. The aggregate in these features tends to become finer near the surface, with fine to coarse gravel being concentrated in the lower levels of some of the pits. Varying amounts of silt and clay may be associated with these deposits, especially at the surface. The aggregate found in the glaciolacustrine delta deposits is generally more uniformly bedded than the subaqueous fan material. Selected Sand and Gravel Resource Area 2 consists of well-stratified sand and gravel of deltaic origin.

There are also some complex deposits within the report area which exhibit characteristics of both ice-contact and deltaic features. Selected Sand and Gravel Resource Areas 4 and 10 were deposited in close associ-

ation with glacial ice and have been designated as ice-contact-deltas.

The Selected Sand and Gravel Resource Areas of Primary Significance occupy a total area of 2800 acres (1130 ha). Cultural constraints and previous extraction reduce the area currently available for extraction to 1630 acres (660 ha), containing possible sand and gravel resources of approximately 72.6 million tons (65.9 million tonnes).

Many deposits have also been selected at the secondary level of significance. Although these deposits tend to be more limited with respect to extractive potential than the resources selected at the primary level, they add significantly to the resource base of the report area.

In many parts of the report area, much of the crushable gravel has been depleted and sand now dominates. The main sources of crushable gravel are outwash, subaqueous fan, deltaic and ice-contact-deltaic features located in the geographic townships of Macauley, McLean, Muskoka and Morrison. In both the towns of Bracebridge and Gravenhurst, large tracts of land contain little or no aggregate resources. Consequently, aggregate supplies may have to be transported lengthy distances to supply construction needs in certain areas.

During the field investigation numerous samples were taken from pit faces, test pits and other exposures. The samples were analyzed for grain size distribution (Figures 3a to 12b) and petrographic numbers (Table 6). The petrographic analyses were performed in the testing laboratory of the Ministry of Transportation's North Bay Regional Office. The grain size analyses were conducted in either the Ministry of Transportation Laboratory or in the Geoscience Laboratory, Ontario Geological Survey.

In general, the aggregate in the project area is considered hard and durable, and is generally of sufficient quality for uses including Granular Base Course (GBC) A, 16 mm crushed stone and asphaltic aggregate, where sufficient quantities of crushable gravel are available. However, the presence of brittle and friable gneiss fragments in the gravel may limit some of the higher specification uses of the aggregate in some localities. In some of the area's pits, selective extraction measures are recommended to avoid sections containing abundant clay, silt and/or very fine sand beds. Laminated clay layers often overlie the sand and gravel, and these layers should be removed to avoid contamination of the underlying aggregate.

The results of the petrographic analyses generally indicate that the gravel quality in the samples was good and petrographically suitable for use in granular base course and 16 mm crushed stone products. However, the hot-mix and concrete petrographic numbers ranged from 167 to 211. Records on file with the Ministry of Transportation (MTO) also indicate variable results for the local aggregates for hot-laid and concrete petrographic numbers as well as for Los Angeles Abrasion and Impact losses and Magnesium Sulphate Soundness losses. High Los Angeles Abrasion and Impact losses

and high hot-mix and concrete petrographic numbers are largely attributed to the presence of the friable and brittle fragments. The local aggregates perform well, however, in asphalt pavements in the field. Consequently, MTO has modified the aggregate specifications to permit losses up to 50 percent for the Los Angeles Abrasion and Impact test, and a maximum petrographic number of 180 for Hot-Laid (HL) No. 4 stone (Rogers 1985).

Although the aggregate from this area may meet MTO aggregate testing specifications based on field performance the local gravels are not accepted by MTO for use in portland cement concrete which will be exposed to de-icing salts. There can be a bonding problem between the cement and the gravel which may eventually result in spalling of the concrete. Consequently, crushed limestone aggregate has been imported from northern Simcoe County for use in the construction of bridge structures in the area.

A. TOWN OF BRACEBRIDGE

SELECTED SAND AND GRAVEL RESOURCE AREAS (MAP 2A)

Selected Sand and Gravel Resource Area 1

Selected Sand and Gravel Resource Area 1 is a large outwash deposit located in the northern part of the geographic township of Macaulay. The deposit is a relatively flat feature and is situated along the North Branch Muskoka River. Three pits have been opened in the Resource Area. At the time of the field investigation, faces in pit no. 21 ranged from 15 to 30 feet (5 to 9 m). The field estimated gravel content in the pit faces ranged from 30 to 60 percent. A sample of the material taken from the pit contained 52 percent gravel, 46 percent sand and 2 percent fines (Figure 4a). The faces generally exposed horizontally stratified, fine to coarse gravel and fine to coarse sand. The material appears well suited for the production of a variety of aggregate products including crushed stone.

Test hole MU-TH-1 was excavated in the floor of pit no. 21 and test holes MU-TH-2, MU-TH-3 and MU-TH-4 were completed in the southern part of the Resource Area near the North Branch Muskoka River. Between 2 and 13 feet (1 and 4 m) of predominantly fine to coarse gravel was uncovered in the test holes. This material was sampled from test holes MU-TH-1 to MU-TH-3 and found to contain between 42 and 65 percent gravel which is well suited for crushing (Figures 7a and 8a). Similar quality aggregate may be available elsewhere in the deposit. Geophysical traverse lines MU-GT-4 to MU-GT-7 were carried out in Area 1. The data obtained from these lines indicate that aggregate may extend to a considerable depth below the surface in parts of the area. The depth to bedrock may be variable in the deposit.

Resource Area 1 occupies 450 acres (182 ha). Cultural constraints and previous extraction reduce the

area currently available for extraction to 390 acres (158 ha). Assuming an average deposit thickness of 30 feet (9 m), aggregate resources are estimated to be 29.2 million tons (26.5 million tonnes). Access to Area 1 is provided by a gravel-surfaced access road.

Selected Sand and Gravel Resource Area 2

Selected Sand and Gravel Resource Area 2 is a glaciolacustrine delta deposit situated in the northern part of the geographic township of Macaulay, near Bonnie Lake. Pit no. 18 has been opened in the resource area. Twelve feet (4 m) of fine to coarse, well-stratified gravel is exposed in the pit. A sample taken from this pit contained 61 percent gravel, 38 percent sand and 1 percent fines (Figure 3a). MTO reports that the material in pit no. 18 is suitable for most uses including granular base course, 16 mm crushed stone and HL No. 4 and 8 stone. In sections, sand control may be necessary for crushing, and the sand fraction of the aggregate would require blending for asphaltic use. Oversize clasts should be removed or crushed in a primary crusher. During field investigation, aggregate was being actively extracted from the pit. Portable crushing equipment was being used to process the aggregate for use in road maintenance. The deposit is considered to be well suited as a local source of road-building and construction aggregate.

Resource Area 2 occupies approximately 22 acres (9 ha), of which 11 acres (4 ha) are considered currently available for extraction. Assuming an average deposit thickness of 12 feet (4 m), aggregate resources are estimated to be 0.3 million tons (0.3 million tonnes). Excellent access is provided to Resource Area 2 via a township road.

Selected Sand and Gravel Resource Area 3

A large glaciofluvial outwash deposit located near the former town of Bracebridge has been selected at the primary level of significance. This deposit is well situated with respect to the former town of Bracebridge market and has been a traditional source of aggregate in the report area. Eleven pits have been opened in Resource Area 3. Faces in pit nos. 28 and 30 to 39 ranged in height from 5 to 35 feet (1.5 to 11 m) and exposed variable material ranging from coarse crushable gravel to silty fine sand. Fine to coarse gravel is generally concentrated in lenses in the upper sections of many of the pits in Area 3. Similar aggregate may be available elsewhere in the deposit. Some of the pits are largely depleted and the remaining aggregate shows a wide variation in grain size. Samples of the material taken from the upper sections of pit nos. 32 and 37 contained 36 and 37 percent gravel, respectively (Figures 4a and 5a). Bedrock is exposed in the floor of pit no. 32. The depth to bedrock may be variable in the undeveloped parts of Area 3. Consequently, subsurface investigation is recommended prior to further extractive development.

MTO reports that the aggregate extracted from the deposit is generally suitable for such uses as granular base course, 16 mm crushed stone and HL No. 4 and 8 stone. The abundance of sand in sections of the pits has

necessitated the use of selection and sand control measures during crushing operations. Oversize clasts should be removed or crushed to suitable size ranges before they can be used as aggregate. Winter sand has been produced from pit no. 32 and in the majority of the pits the sand fraction of the aggregate requires blending for use in hot-laid asphalt. Silt seams and lenses were noted in some of the pits and should be avoided during extraction. MTO has excavated several test holes in the vicinity of pit nos. 28, 34 and 39. The test holes uncovered varying depths of predominantly sandy aggregate with lenses of fine to coarse gravel.

This outwash deposit occupies approximately 310 acres (125 ha), presently available for extraction. Assuming an average deposit thickness of 20 feet (6 m), the available aggregate resources are considered to be 15.5 million tons (14.1 million tonnes). Resource Area 3 is readily accessible via King's Highway 11.

Selected Sand and Gravel Resource Area 4

Selected Sand and Gravel Resource Area 4 is an ice-contact-delta deposit located near the hamlet of Muskoka Falls. This complex deposit exhibits characteristics of both ice-contact and glaciolacustrine delta features. It extends southward into the town of Gravenhurst where it has been designated as Selected Sand and Gravel Resource Area 10 (Map 2B).

Three pits have been opened in Area 4. The 5- to 20-foot (1.5 to 6 m) faces in the pits exposed fine to coarse gravel with a field estimated gravel content ranging from 30 to 60 percent. A sample of the material taken from pit no. 9 contained 55 percent gravel, 44 percent sand and 1 percent fines (Figure 3a). The aggregate in the pits is considered well suited for the production of a variety of aggregate products, including crusher-run gravel. During field investigation, portable screening and crushing equipment were being used to process the aggregate for use in road maintenance.

Area 4 occupies 36 acres (15 ha), of which 6 acres (2 ha) are considered presently available for extraction. Based on an average deposit thickness estimate of 20 feet (6 m), the available aggregate resources are considered to be 0.3 million tons (0.3 million tonnes). Resource Area 4 is readily accessible via District Road 4 and King's Highway 11.

Selected Sand and Gravel Resource Area 5

Selected Sand and Gravel Resource Area 5 is a glaciofluvial outwash deposit located immediately adjacent to Resource Area 4 in the geographic township of Muskoka. The deposit is part of a major glaciofluvial system that extends southward into the town of Gravenhurst where it has been designated as Selected Sand and Gravel Resource Area 9 (Map 2B). Area 5 is expected to contain similar materials and to have a comparable resource potential as described for Resource Area 9 in the town of Gravenhurst section of this report.

Approximately 5 acres (2 ha) are available for extraction in Resource Area 5. Assuming an average deposit thickness of 10 feet (3 m), aggregate resources total an estimated 0.1 million tons (less than 0.1 million tonnes). Access to the Area is excellent.

Selected Sand and Gravel Resource Area 6

A glaciofluvial outwash deposit located near the former town of Bracebridge has been selected at the primary level of significance. Pit nos. 55 and 56 have been opened in the Resource Area. Faces in these pits ranged in height from 20 to 45 feet (6 to 14 m) and exposed mainly sandy aggregate which is best suited for local pit-run uses. Limited amounts of crushable gravel, however, may be available from localized gravel pockets in the deposit with appropriate processing. A sample of the material in pit no. 56 contained 27 percent gravel, 71 percent sand and 2 percent fines (Figure 5a). Lenses of laminated silt were noted near the surface in pit no. 55 and should be avoided during extraction. MTO reports that products produced from pit no. 55 include GBCC and fill. Some higher quality sand products could possibly be produced with blending.

Resource Area 6 occupies an estimated available area of 30 acres (12 ha). Assuming an average deposit thickness of 30 feet (9 m), the available aggregate resources are considered to be 2.2 million tons (2.0 million tonnes). Resource Area 6 is readily accessible via King's Highway 11 and District Road 37.

Selected Sand and Gravel Resource Area 7

Selected Sand and Gravel Resource Area 7 is a gravel outwash deposit located in the southwestern part of the geographic township of McLean, along the South Branch Muskoka River. Four pits have been developed in the deposit. Faces in pit nos. 88 to 91 ranged in height from 10 to 15 feet (3 to 5 m) and generally exposed fine to coarse gravel overlying fine to coarse sand with minor amounts of fine gravel. A sample of the material from pit no. 88 contained 45 percent gravel, 54 percent sand and 1 percent fines (Figure 6a). This material appeared well suited for the production of a variety of aggregate products including crushed gravel, with appropriate processing.

Resource Area 7 occupies 160 acres (65 ha), of which 130 acres (53 ha) are considered suitable for extraction. Assuming an average deposit thickness of 15 feet (5 m), available aggregate resources are estimated to be 4.9 million tons (4.4 million tonnes). The deposit is readily accessible via District Road 14.

Selected Sand and Gravel Resource Area 8

Selected Sand and Gravel Resource Area 8 is an outwash deposit located near the eastern border of the geographic township of Oakley, along the Black River. Pit no. 102 has been opened in the deposit. The 10- to 20-foot (3 to 6 m) faces in the pit exposed fine to coarse gravel with a field estimated gravel content ranging from 0 to 40 percent. Silt seams and lenses are common in parts of the pit and should be avoided during extrac-

tion. Oversize clasts should be removed or crushed in a primary crusher. Lenses of coarse gravel within the pit are potential sources of crushable material if sand control and selective extraction measures are employed. The Resource Area is a valuable source of aggregate because coarse material is generally scarce in the remainder of the geographic township of Oakley.

Resource Area 8 has an available area of approximately 65 acres (26 ha). With an average deposit thickness of 15 feet (5 m), estimated resources of sand and gravel are 2.4 million tons (2.2 million tonnes). Good access to the Resource Area is provided by King's Highway 118 and by gravel-surfaced roads.

RESOURCE AREAS OF SECONDARY SIGNIFICANCE (MAP 2A)

Several outwash and delta deposits and one ice-contact deposit have been selected at the secondary level of significance in the town of Bracebridge. Two glaciofluvial outwash gravel deposits have been designated as secondary resources in the geographic township of Macaulay. The deposits are located along the North Branch Muskoka River in the northern part of the township. No pits have been established in either of the deposits and deposit boundaries have been delineated largely through aerial photograph interpretation. In places the river has cut into the deposits and these cuts provide the bulk of available subsurface data. The cuts reveal approximately 8 to 12 feet (2 to 4 m) of slumped sand and gravel. In places coarse gravel is the dominant sediment exposed, while sand is abundant in other sections. The material appears to be well suited for the production of a variety of aggregate products including crusher-run gravel with appropriate processing. Subsurface investigation is recommended for these features to assess the quality of the aggregate at depth.

A glaciolacustrine delta deposit located near Springdale Park in the geographic township of Macaulay has also been selected at the secondary level of significance. Pit nos. 24 and 25 have been opened in the deposit and have been traditional suppliers of aggregate in the report area. At the time of field investigations, face heights in the pits ranged from 15 to 40 feet (5 to 12 m). Material exposed in the pits ranged from silty sand to gravel which is coarse enough for crushing purposes. Higher concentrations of gravel generally occur in the upper, flat-lying part of the delta. Sections of the pits were largely depleted of crushable gravel and the remaining aggregate shows a wide variation in grain size. A sample taken of the material in pit no. 24 contained 35 percent gravel, 64 percent sand and 1 percent fines (Figure 4a). MTO data indicate that material extracted from the pits is suitable for a range of road-building and construction products including granular base course, 16 mm crushed stone and HL No. 4 stone. Selective extraction and sand control measures will be required in sections during crushing operations. The sand fraction of the aggregate requires blending for use in hot-laid asphalt. The presence of silt seams and excessive quanti-

ties of very fine sand would restrict the use of the sand from the pits. MTO has also excavated several test holes in the vicinity of these pits. The test holes uncovered up to 18 feet (5 m) of material similar to that exposed in the pit faces. The depth of extraction in parts of the deposit may be limited by the presence of bedrock and by a potentially high water table.

The final deposit selected at the secondary level in the geographic township of Macaulay is a complex feature deposited in an ice-contact and delta environment. The deposit is located immediately east of the former town of Bracebridge and pit no. 40 provides subsurface data for this area. The western face of pit no. 40 ranged in height from 40 to 50 feet (12 to 15 m) and exposed horizontally bedded, fine to coarse gravel and fine to coarse sand. In places, the gravels were overlain by laminated silts that should be avoided during extraction. Bedrock was noted in the eastern pit face. MTO reports that products produced from pit no. 40 include GBC A, C and HL No. 4 stone with appropriate processing. The sand fraction of the aggregate requires blending for use in hot-laid asphalt. During field investigations, large quantities of sand were being extracted from the surface of the deposit for use as foundation backfill for a bridge overpass near Roxborough. Twenty-six test holes were excavated by MTO to a maximum depth of 25 feet (8 m) in the deposit. Twenty-one of the test holes uncovered mainly sand while the remaining five generally uncovered fine to coarse gravel potentially suitable for a wide range of aggregate products.

A small sand outwash deposit located near Muskoka Falls in the geographic township of Muskoka has been selected as a secondary resource area. The deposit is part of a major glaciofluvial system that extends southward into the town of Gravenhurst (Map 2B). The deposit is expected to contain similar materials and have a comparable resource potential as described for the secondary area in the town of Gravenhurst section of this report.

Two glaciofluvial outwash deposits have been designated as secondary resources in the geographic township of Draper. These deposits are located north of Prospect Lake, along the South Branch Muskoka River. Pit nos. 72 to 76 have been identified in the deposits. Faces in these pits ranged in height from 5 to 20 feet (1.5 to 6 m) and exposed variable gravel contents. A sample of the material from pit no. 74 contained 20 percent gravel, 79 percent sand and 1 percent fines (Figure 5a). Fine to medium gravel was contained near the surface of these deposits and below this, the material consisted largely of fine to coarse sand with sporadic lenses of silt. Much of the gravel has already been removed, down to the underlying bedrock. The remaining aggregate appears well suited for pit-run uses. A variable bedrock surface and potentially high water table may limit extraction in parts of the deposit.

Two glaciolacustrine delta deposits located near Gartersnake Lake, in the southern part of the geographic township of Draper, have also been selected at the secondary level of significance. Pit nos. 80 to 82 and

geophysical traverse line MU-GT-10 provide subsurface data for these secondary deposits. Pit no. 82 has been opened in the delta deposit immediately adjacent to Gartersnake Lake and contains 10 to 20 feet (3 to 6 m) of gravelly sand. The upper 1 to 5 feet (0.3 to 1.5 m) of the face contains higher concentrations of gravel. Field estimates of gravel contents were generally less than 30 percent. Data obtained from seismic line MU-GT-10 indicate that aggregate may extend to a considerable depth. In general, the aggregate in these delta deposits is considered best suited for pit-run uses and fill. Limited amounts of crushable gravel may also exist in isolated pockets. The deposits are considered to be important sources of sand and gravel in this part of the geographic township and will be valuable for future use.

One outwash gravel deposit has been selected at the secondary level of significance in the geographic township of McLean. The deposit is located north of Selected Resource Area 7 and contains pit no. 87. Five to six feet (1.5 to 1.8 m) of fine to coarse gravel and medium to coarse sand was exposed in the pit. Field estimates of gravel contents were as high as 50 percent. The material in the pit appears generally suitable for crushing purposes as well as for pit-run use. Additional testing should be undertaken to determine the quality of the material in the undeveloped parts of the deposit.

Three outwash gravel deposits have been designated as secondary resources in the geographic township of Oakley. The deposits are located near Bigwind Lake Provincial Park, along Black River. Pit nos. 98 and 99 and seismic line MU-GT-11 provide subsurface data for these deposits. Material exposed in the pits appeared to be well suited for local aggregate use. Pit faces ranged in height from 5 to 15 feet (1.5 to 5 m) and contained lenses of fine to coarse gravel. Field estimates of gravel contents within the lenses were as high as 50 percent. Nine test holes were excavated by MTO near pit no. 99. Six of the test holes uncovered up to 11.5 feet (3.5 m) of medium to coarse gravel considered to be suitable for use as pit-run material. Small amounts of crushable gravel may be available with selective extraction of the seams and pockets of coarser material.

B. TOWN OF GRAVENHURST

SELECTED SAND AND GRAVEL RESOURCE AREAS (MAP 2B)

Selected Sand and Gravel Resource Area 9

Selected Sand and Gravel Resource Area 9, located in the geographic township of Muskoka, is part of a major glaciofluvial outwash system that extends northward into the town of Bracebridge where it has been designated Resource Area 5 (Map 2A). The deposit underlies the northern part of the Muskoka Airfield where pit no. 122 and seismic line MU-GT-13 provide subsurface data for this feature. The 5- to 10-foot (1.5 to 3 m) faces in pit no. 122 exposed well-rounded coarse gravel and medium to coarse sand. Field estimates of the gravel con-

tent ranged from 30 to 70 percent. A sample of the material taken from pit no. 122 contained 61 percent gravel, 38 percent sand and 1 percent fines (Figure 10a). The sample was crushable because 38 percent of the material was larger than 26.5 mm in size. Although MTO information is not available for this deposit the material appears well suited for the production of a variety of aggregate products including crushed gravel. Oversize clasts should be removed or crushed in a primary crusher to be used as aggregate. Data for seismic line MU-GT-13 indicate the possibility that aggregate may extend to a considerable depth.

Area 9 occupies 43 acres (17 ha), of which 8 acres (3 ha) are considered presently available for extraction. Based on an average deposit thickness estimate of 10 feet (3 m), the available aggregate resources are considered to be 0.2 million tons (0.2 million tonnes). King's Highway 11 and District Road 41 bisect the Resource Area and provide excellent access.

Selected Sand and Gravel Resource Area 10

Selected Sand and Gravel Resource Area 10 is an ice-contact-delta deposit located along the northern boundary of the geographic township of Muskoka. This complex deposit exhibits characteristics of both ice-contact and glaciolacustrine delta features. This deposit extends northward into the town of Bracebridge where it has been designated Resource Area 4 (Map 2A). Pit no. 121 has been opened in the deposit. Although the 10- to 15-foot (3 to 5 m) faces in the pit were largely depleted and overgrown, fine to coarse gravel was exposed in sections of the pit. Field estimates of gravel content from those sections ranged from 30 to 60 percent. MTO reports that products produced from pit no. 121 include GBC A with appropriate processing.

The deposit occupies approximately 11 acres (4 ha), of which 1 acre (less than 1 ha) is considered presently available for extraction. Based on an average deposit thickness of 20 feet (6 m), the available aggregate resources are considered to be less than 0.1 million tons (less than 0.1 million tonnes). The Resource Area is readily accessible from District Road 41.

Selected Sand and Gravel Resource Area 11

An esker ridge located near Muskoka Beach, in the central part of the geographic township of Muskoka constitutes Selected Sand and Gravel Resource Area 11. The ridge exhibits local relief varying from less than 5 feet (1.5 m) at its eastern end to over 20 feet (6 m) towards the west. Pit nos. 138 and 139 have been opened in this feature. Faces in pit no. 139 ranged in height from 20 to 25 feet (6 to 8 m) and exposed lenses of fine to coarse gravel and fine to coarse sand. Field estimated gravel contents ranged from 30 to 50 percent. Coarse gravel was concentrated in lenses near the surface of the pit. The pit is considered well suited for the production of a variety of aggregate products, including crushed stone, with suitable processing.

Resource Area 11 occupies 11 acres (4 ha), of which 4 acres (2 ha) are considered available for extraction. As-

suming an average deposit thickness of 15 feet (5 m), sand and gravel resources total approximately 0.2 million tons (0.2 million tonnes). Access to the area is excellent.

Selected Sand and Gravel Resource Area 12

Selected Sand and Gravel Resource Area 12, located in the geographic township of Muskoka, consists of two glaciofluvial outwash gravel deposits, labelled 12a and 12b on Map 2B. Pit nos. 129 and 130 have been opened in Resource Area 12a. Faces in pit no. 130 ranged in height from 20 to 25 feet (6 to 8 m) and exposed variable gravel contents. Bedrock was noted in the eastern faces of both pits and water was observed on the floor of pit no. 130. The lenses of medium to coarse gravel that occurred in pit no. 130 appeared well suited for crushing. MTO has tested the material from pit no. 130 and reports that it is suitable for uses including granular base course, 16 mm Crushed Type "A" and HL No. 4 stone, with suitable processing. The sand fraction of the aggregate would require blending for asphaltic use. Oversize clasts should be removed or crushed for the production of GBC C. MTO has excavated 13 test holes in the vicinity of pit no. 130. Lenses of medium to coarse gravel were encountered in some of the test holes and may be suitable for a wide range of aggregate products including crushed gravel.

Pit nos. 127 and 128 have been opened in Resource Area 12b. Faces in these pits ranged in height from 5 to 12 feet (1.5 to 4 m) and were largely overgrown. Field estimates of gravel contents were as high as 50 percent in sections. MTO reports that aggregate from pit no. 128 is suitable for use as GBC A, B and C, 16 mm Crushed Type "A" and HL No. 4 coarse aggregate with sand control. The sand fraction of the aggregate would require blending for use in hot-laid asphalt. Oversize clasts should be removed or crushed in a primary crusher. Test holes excavated by MTO in the vicinity of pit no. 128 uncovered lenses of predominantly coarse gravel with some oversize material. The depth of extraction in parts of the deposit may be limited by the presence of bedrock or by a potentially high water table.

Selected Sand and Gravel Resource Areas 12a and 12b occupy an available area of 17 acres (7 ha). Assuming an average deposit thickness of 20 feet (6 m) for Area 12a, and 8 feet (2 m) for Area 12b, available aggregate resources are estimated to be 0.4 million tons (0.4 million tonnes). District Road 41 provides excellent access to the deposits.

Selected Sand and Gravel Resource Area 13

Selected Sand and Gravel Resource Area 13 includes three subaqueous fan deposits located along King's Highway 11 in the geographic township of Morrison. Resource Area 13 has been subdivided into Areas 13a, 13b and 13c, of which Area 13b is the most extensive.

Pit nos. 160, 162 to 165, and 167 to 169 have been opened in Resource Area 13a. Faces in the pits ranged in height from less than 5 to 25 feet (less than 1.5 to 8 m).

Many of these pits were extensively used in the past and faces were largely overgrown. Bedrock was noted in pit nos. 165, 167 and 168. Generally, the aggregate in pit no. 162 becomes finer near the surface, with fine to coarse gravel being concentrated in pockets in the lower levels of the pit. MTO has tested the aggregate from pit nos. 162 and 167 to 169 and report that products produced from these pits include GBC B and C, and fill. The aggregate appeared well suited for local use. The sand fraction of the aggregate requires blending for use in hot-laid asphalt. Limited amounts of crushable gravel may be available from localized gravel pockets in the deposit. The material from pit no. 168 has been used for the production of 16 mm Crushed Type "A" stone. MTO has excavated several test holes up to 15 feet (5 m) in depth in the vicinity of pit no. 167. Fine to coarse gravel was uncovered in some of the test holes and the material was found to be acceptable for a wide range of aggregate products including crushed gravel with appropriate processing. Similar quality aggregate may be available elsewhere in the deposit. Subsurface investigation would, however, be required in this feature to assess the quality of the aggregate at depth. Data obtained from geophysical traverse line MU-GT-20 indicate the possibility that the aggregate may extend to a considerable depth in parts of the deposit.

Pit nos. 170 to 175 have been opened in Resource Area 13b. Faces in these pits ranged in height from less than 5 to 15 feet (less than 1.5 to 5 m) and contained variable material ranging from pockets of coarse gravel to silty fine sand. Many of the faces in the pits were overgrown and bedrock was observed in the floor of pit nos. 170 and 175. Field estimated gravel contents were as high as 50 percent. A sample taken from a gravel pocket in the lower section of pit no. 170 contained 40 percent gravel and 60 percent sand (Figure 11a, Pit 170a). The upper sand unit in pit no. 170 was also sampled and contained 93 percent sand and 7 percent fines (Figure 11a, Pit 170b). The aggregate appeared well suited for local use. MTO reports that products produced from pit no. 175 include granular base course, 16 mm crushed stone and fill. Selection and sand control would be necessary for crushing, and blending would be required for the production of asphalt sand. Oversize clasts should be removed or crushed in a primary crusher. Several test holes have been excavated by MTO in the vicinity of pit no. 175. Pockets of coarse gravel were uncovered in some of the test holes and the material was found to be acceptable for uses including GBC A with sand control. Information obtained from seismic line MU-GT-22 indicates that 9 feet (2.7 m) of sand and gravel overlie bedrock near pit no. 171. The depth of extraction in the undeveloped parts of Area 13b may be restricted in places by bedrock or by a high water table.

Pit nos. 178 and 179 and geophysical traverse line MU-GT-23 provide subsurface information for Resource Area 13c. Recent excavation in the southern part of pit no. 179 revealed approximately 5 to 10 feet (1.5 to 3 m) of fine to coarse sand overlying a 5-foot (1.5 m) lens of fine to coarse gravel. Silt and silty fine sand overlies

portions of the deposit and this material should be removed prior to extraction to avoid contamination of the underlying gravels. A sample from the lower gravel lens contained 40 percent gravel, 59 percent sand and 1 percent fines (Figure 11a). Results of analysis of this sample indicate that the aggregate may be best suited for use as GBC B and C and fill. Blending would likely be required to produce asphaltic sand products. In addition, selective extraction of gravel suitable for crushing may be possible from the lower gravel unit. Data for seismic line MU-GT-23 indicate the possibility that aggregate extends to a considerable depth.

Resource Area 13 totals approximately 1060 acres (430 ha), of which 600 acres (243 ha) are currently available for extraction. Assuming an average thickness of 15 feet (5 m) for Areas 13a and 13c, and 8 feet (2 m) for Area 13b, aggregate resources are estimated to be 15.7 million tons (14.2 million tonnes). The Resource Area is readily accessible from King's Highway 11 and District Road 19.

Selected Sand and Gravel Resource Area 14

Selected Sand and Gravel Resource Area 14 is located within the geographic township of Ryde. Resource Area 14 consists of four outwash gravel deposits which are labelled 14a to 14d on Map 2B.

Three pits have been opened in Resource Area 14a. In pit no. 212, approximately 5 feet (1.5 m) of fine to coarse gravel overlies 5 feet (1.5 m) of fine to coarse sand. Field estimated gravel contents were as high as 50 percent. Similar material was observed in the 5- to 10-foot (1.5 to 3 m) faces of pit no. 213, although the upper gravel layer is less than 5 feet (1.5 m) thick in places. If selective extraction measures are employed, the aggregate in pit nos. 212 and 213 is considered well suited for the production of a variety of aggregate products, including crushed stone. Oversize clasts should be removed or crushed in a primary crusher. Bedrock was exposed in the floor of pit no. 213. The depth to bedrock may also be variable in the undeveloped parts of Area 14a.

Pit no. 208 has been opened in Resource Area 14b. Faces in pit no. 208 were largely overgrown, however, in places they exposed up to 8 feet (2 m) of fine to coarse gravel that appeared well suited for local use. Bedrock was observed in the pit floor and the depth to bedrock may be variable in the deposit. A large part of Area 14b is undeveloped and additional subsurface testing should be undertaken to ascertain the nature of the material located at depth prior to extractive development.

Resource Area 14c is located near the community of Houseys Rapids and contains pit no. 202. Faces in the pit ranged from 5 to 15 feet (1.5 to 5 m) and exposed horizontally bedded sandy gravel. Dredging operations in the floor of pit no. 202 have uncovered additional quantities of fine to coarse gravel from below the water table. A sample of the dredged material contained 42 percent gravel, 56 percent sand and 2 percent fines (Figure 12a). This material appeared suitable for uses including GBC

B and C, and fill. Blending would likely be required to produce asphaltic sand products.

Resource Area 14d is located near the community of Riley Lake and pit nos. 197 and 198 have been opened in the deposit. Faces in pit no. 198 ranged in height from 5 to 15 feet (1.5 to 5 m) and exposed fine to coarse gravel. Pit faces were largely overgrown and bedrock was observed in a pit face. Field estimated gravel contents were as high as 60 percent in some sections of the pit. The gravel is likely to be suitable for the production of a variety of aggregate products.

Approximately 52 acres (21 ha) are currently available for extraction in Resource Area 14. Assuming an average deposit depth of 8 feet (2 m) for Areas 14a and 14b, 15 feet (5 m) for Area 14c, and 10 feet (3 m) for Area 14d, aggregate resources are estimated to be 1.2 million tons (1.1 million tonnes). Access to the area is provided by District Road 6 and paved township roads.

RESOURCE AREAS OF SECONDARY SIGNIFICANCE (MAP 2B)

Sixteen deposits in the town of Gravenhurst have been selected as resource areas of secondary significance. Three glaciofluvial outwash deposits located in the northeastern part of the geographic township of Muskoka have been selected at the secondary level of significance. Pit nos. 123, 126 and 137 and geophysical traverse lines MU-GT-14, MU-GT-15 and MU-GT-18 provide subsurface data for the large outwash deposit that underlies the Muskoka Airfield. Faces in pit nos. 126 and 137 ranged in height from 5 to 10 feet (1.5 to 3 m) and exposed predominantly sandy fine to medium gravel. Material observed on the surface of the deposit varied from sand to sandy gravel, and in certain areas the aggregate may thinly overlie bedrock. Information obtained from the seismic data indicates that between 7 and 11 feet (2 and 3 m) of sand and gravel overlies the water table in parts of the deposit. Water was observed on the floor of pit nos. 123 and 137. Aggregate from this deposit appears well suited for pit-run uses and similar material may be available from the undeveloped parts of the deposit. A high water table may limit the depth of extraction in this deposit. The outwash deposit in which pit nos. 124 and 125 have been opened consists of material ranging from silty fine sand to coarse crushable gravel. Faces in the pits ranged in height from 5 to 10 feet (1.5 to 3 m) and coarse gravel was concentrated near the surface of pit no. 125. MTO data indicate that aggregate from pit no. 125 has been used for GBC A and C. With blending, the sand would be suitable for hot-laid asphalt production. MTO has also excavated 15 test holes in the vicinity of pit no. 125. Test holes showed approximately 15.5 feet (4.7 m) of aggregate. The material uncovered was mainly sand, with one pocket of coarse gravel. The material revealed in the test holes is considered best suited for uses including GBC C and fill. Pit nos. 133 and 134 have been opened in the final outwash deposit selected at the secondary level in the geographic township of Muskoka. Faces in pit no. 134 exposed up to 12 feet (4 m) of predominantly sandy aggregate. Fine to coarse

gravel and medium to coarse sand were concentrated near the surface of the pit. Occasional lenses of silty fine sand were also observed. MTO reports that products produced from pit no. 134 include granular base course, 16 mm crushed stone and HL No. 4 stone. The pit is, however, largely depleted of crushable gravel. The presence of silt seams and excessive quantities of fine sand may restrict the use of the sand from pit no. 134. Blending would be required for the production of asphalt sand. Oversize material should be either removed or crushed in a primary crusher. Forty-one test holes were excavated by MTO to a maximum depth of 11.5 feet (3.5 m) in the vicinity of pit no. 134. Most of the test holes uncovered mainly sand while only three uncovered pockets of coarse gravel beneath a surface veneer of sand. The material revealed in the test holes is considered best suited for hot-laid blending sand and sand cushion.

An esker ridge and two ice-contact deposits located near the hamlet of Muskoka Beach have also been selected at the secondary level. The esker ridge is situated near Brydon Bay and is a continuation of Selected Resource Area 11. This unopened deposit has good potential as an aggregate source. A roadside exposure along the northern part of the feature reveals approximately 5 to 6 feet (1.5 to 1.8 m) of fine to coarse gravel that appears well suited for the production of a variety of aggregate products. Two hummocky ice-contact deposits located near Muskoka Beach have good potential as aggregate sources in the geographic township of Muskoka. Although no pits have been opened in the deposits, roadside exposures revealed up to 10 feet (3 m) of irregularly bedded, fine to coarse gravel. The aggregate is considered well suited for both pit-run and crusher-run uses. Selective extraction and sand control measures may be required for crushing. A primary crusher may be beneficial in utilizing the oversize material. Subsurface investigation would be required in these features, however, to assess the quality of the aggregate at depth. Recreational activities, including golfing and skiing, may inhibit extractive development in parts of the deposits.

Three glaciolacustrine delta deposits located near the former town of Gravenhurst are the final deposits selected at the secondary level in the geographic township of Muskoka. Pit no. 140 has been opened in the delta deposit located near Brydon Bay. The 10- to 12-foot (3 to 4 m) faces in the pit revealed fine to coarse gravel interstratified with fine to coarse sand. The field estimated gravel content ranged from 30 to 50 percent. The material appears well suited for pit-run uses and similar material may be available from the undeveloped parts of the deposit. Pit nos. 141 to 148 provide subsurface data for the extensive delta deposit located near the former town of Gravenhurst. Faces in these pits ranged in height from 5 to 30 feet (1.5 to 9 m) and exposed variable material ranging from lenses of coarse gravel to silty fine sand. A sample of the material from pit no. 146 contained 42 percent gravel, 56 percent sand and 2 percent fines (Figure 10a). Many of the pits within the deposit have been traditional sources of aggregate in the past

and much of the crushable gravel resources have been depleted. MTO reports that products produced from pits within this deposit include granular base course, 16 mm crushed stone, HL No. 4 and 8 stone and fill. The sand fraction of the aggregate requires blending for use as asphaltic sand. Test holes excavated by MTO in the vicinity of pit no. 145 indicate that the medium to coarse gravel is generally concentrated in the upper 10 feet (3 m) of the deposit and is underlain predominantly by sand. Residential, commercial and industrial development near District Road 17 may inhibit extractive activity in parts of the deposit.

A glaciolacustrine delta deposit located in the northern part of the geographic township of Morrison has been selected at the secondary level of significance. The deposit is located north of Kilworthy and contains pit no. 166. Twenty to twenty-five feet (6 to 8 m) of predominantly fine gravel interstratified with fine to coarse sand was exposed in the pit faces. Silt seams and lenses were observed in some of the pit faces. Field estimated gravel content was generally less than 20 percent and a sample of the material from the pit contained 18 percent gravel, 81 percent sand and 1 percent fines (Figure 10a). Records on file with MTO indicate that crushed gravel has been produced from the pit, however, it is largely depleted of crushable material. The remaining material appears well suited for pit-run uses. Blending would be required for the production of hot-laid sand. Results of seismic line MU-GT-21 indicate the possibility that aggregate may extend to a considerable depth.

Three subaqueous fan deposits located in the southern part of the geographic township of Morrison have been selected at the secondary level. The deposits are situated between the Kashe and Severn rivers and contain pit nos. 176, 177 and 181 to 190. Faces in the pits ranged in height from less than 5 to 20 feet (less than 1.5 to 6 m). Many of these pits were extensively used in the past and faces were largely overgrown. Faces in the pits generally exposed materials ranging from silty fine sand to coarse gravel. Generally, the aggregate became finer near the surface, with fine to coarse gravel concentrated in pockets in the lower levels of the pits. Bedrock was observed in pit nos. 181, 182 and 184. MTO reports that crushed gravel has been produced from pit nos. 182 and 183, however, they are largely depleted of crushable material. The material in the pits generally appears well suited for local pit-run use. The sand fraction of the aggregate requires blending for asphaltic aggregate. Test holes excavated by MTO in the vicinity of pit no. 183 indicate that bedrock may be encountered at depths between 5.5 and 10.5 feet (1.7 to 3.2 m).

An outwash sand deposit and two outwash gravel deposits located in the geographic township of Ryde have been selected at the secondary level of significance. Pit nos. 204 to 206 have been opened in the outwash sand deposit located near Bass Lake. Faces in these pits ranged in height from 5 to 15 feet (1.5 to 5 m) and were largely overgrown. Pockets of fine to coarse gravel and fine to coarse sand were concentrated near the surface of pit no. 204. Bedrock was noted in the

floors of pit nos. 204 and 206. In general, the aggregate in the deposit appears well suited for pit-run uses. Pit nos. 196 and 215 to 217 have been opened in the outwash gravel deposits located near Coopers Falls and South Longford Lake. Faces in these pits ranged in height from less than 5 to 10 feet (less than 1.5 to 3 m) and generally exposed fine to coarse gravel and fine to coarse sand. Bedrock was exposed in places within pit no. 196 and water was observed on the floor of the pit. A sample of the material from pit no. 216 contained 42 percent gravel, 53 percent sand and 5 percent fines (Figure 12a). These two outwash gravel deposits have good potential as sources of pit-run aggregate, and may contain limited amounts of crushable aggregate.

BEDROCK GEOLOGY AND RESOURCE POTENTIAL

The bedrock in the report area is part of the Grenville Province of the Canadian Shield. The bedrock geology of the area is portrayed at a reconnaissance level in Figure 2. Geological mapping and reports by the following authors were utilized to summarize the bedrock geology of parts of the project area: Hewitt (1967); Wynne-Edwards (1972); Schwerdtner and Waddington (1978); Davidson and Morgan (1981); Culshaw et al. (1983); Martin (1983); Davidson (1984); Davidson et al. (1985); Marmont and Johnston (1987); and Meadows et al. (1987). The report area is underlain by bedrock of the Muskoka Domain of the Central Gneiss Belt (Davidson and Morgan 1981). The prevalent rock type present in the area is migmatitic gneiss. In general, the bedrock of the Muskoka Domain dips to the southeast, some sections of which are relatively straight layered (Davidson and Morgan 1981; Marmont and Johnston 1987). The Muskoka Domain has undergone several phases of deformation and regional medium to high grade metamorphism resulting in a complex geological pattern (Marmont and Johnston 1987). The bedrock geology within the project area has not been mapped extensively because of the complexity of the rocks and the perceived low economic potential of the area (Martin 1983).

At present, no quarries have been opened in the Precambrian bedrock in the towns of Bracebridge and Gravenhurst. However, quarries have been opened in the Central Gneiss Belt in the Parry Sound area to supply crushed stone for a wide range of aggregate products. Much of the report area is underlain by massive-looking, hard and durable bedrock which may be well suited for a variety of aggregate applications. However, the bedrock within the report area may exhibit wide variations with respect to aggregate quality over relatively short distances. Consequently, any site that may be proposed for quarry development should be carefully investigated before extraction occurs. Variations that have an effect on the suitability of rock for use as aggregate in the area include mineralogy, texture and degree of weathering. Highly weathered, brittle and friable rock which is unacceptable for aggregate use may occur within all rock types within the area. Some of the

coarse-grained rocks with mica, quartz and feldspar contents may have bonding problems because the smooth cleavage and fracture surfaces of these minerals hinder the adhesion of asphalt and cement mixes. Stockpile aging may help erode the smooth surfaces of the rocks and allow for better adhesion. This problem may also be circumvented by the addition of chemicals (anti-stripping agents) that can erode the smooth surfaces which allows for better adhesion. Although the bedrock in the area may meet specifications, the local rock may not be accepted by MTO for use in portland cement concrete exposed to de-icing salts. A potential bond problem may exist between the aggregate and cement.

Within the report area, extensive areas occur in which the bedrock outcrops or is covered by thin drift. Therefore, numerous options are available in the selection of sites for potential bedrock extraction.

SUMMARY

The sand and gravel deposits in the towns of Bracebridge and Gravenhurst are the product of glacial activity which occurred during the Late Wisconsin Sub-stage of the Pleistocene Epoch. A number of these deposits which contain significant resources of sand and gravel have been grouped together into fourteen Primary Resource Areas. In addition, numerous deposits of secondary significance, which add considerably to the project area's resource base, have also been selected. Care should be taken to ensure the continued availability of as much of the resource areas as possible.

In general, the project area contains large resources of sandy aggregate and limited resources of crushable gravel. The most significant potential resources of crushable gravel include outwash, subaqueous fan, deltaic and ice-contact-deltaic features located in the geographic townships of Macauley, McLean, Muskoka and Morrison.

The aggregate in the project area is considered hard and durable and is generally suitable for most usual applications. However, use of the material in hot-laid asphalt may be restricted in places by the presence of brittle and friable rock types within the gravel. Local gravels are not accepted by MTO for use in concrete which will be exposed to de-icing salts because there is a bonding problem between the aggregate and the cement which results in concrete deterioration. Consequently, crushed limestone aggregate is imported into the project area from northern Simcoe County to meet demands for high specification aggregate.

Precambrian age bedrock of the Canadian Shield underlies the project area. Highly deformed migmatitic gneisses of indeterminate origin are the most widespread rock type in the project area. The bedrock in the area can exhibit wide variations in aggregate quality. Consequently, site specific testing is recommended prior to extraction.

Enquiries regarding the Aggregate Resources Inventory of the Towns of Bracebridge and Gravenhurst should be directed to the Aggregate Assessment Office,

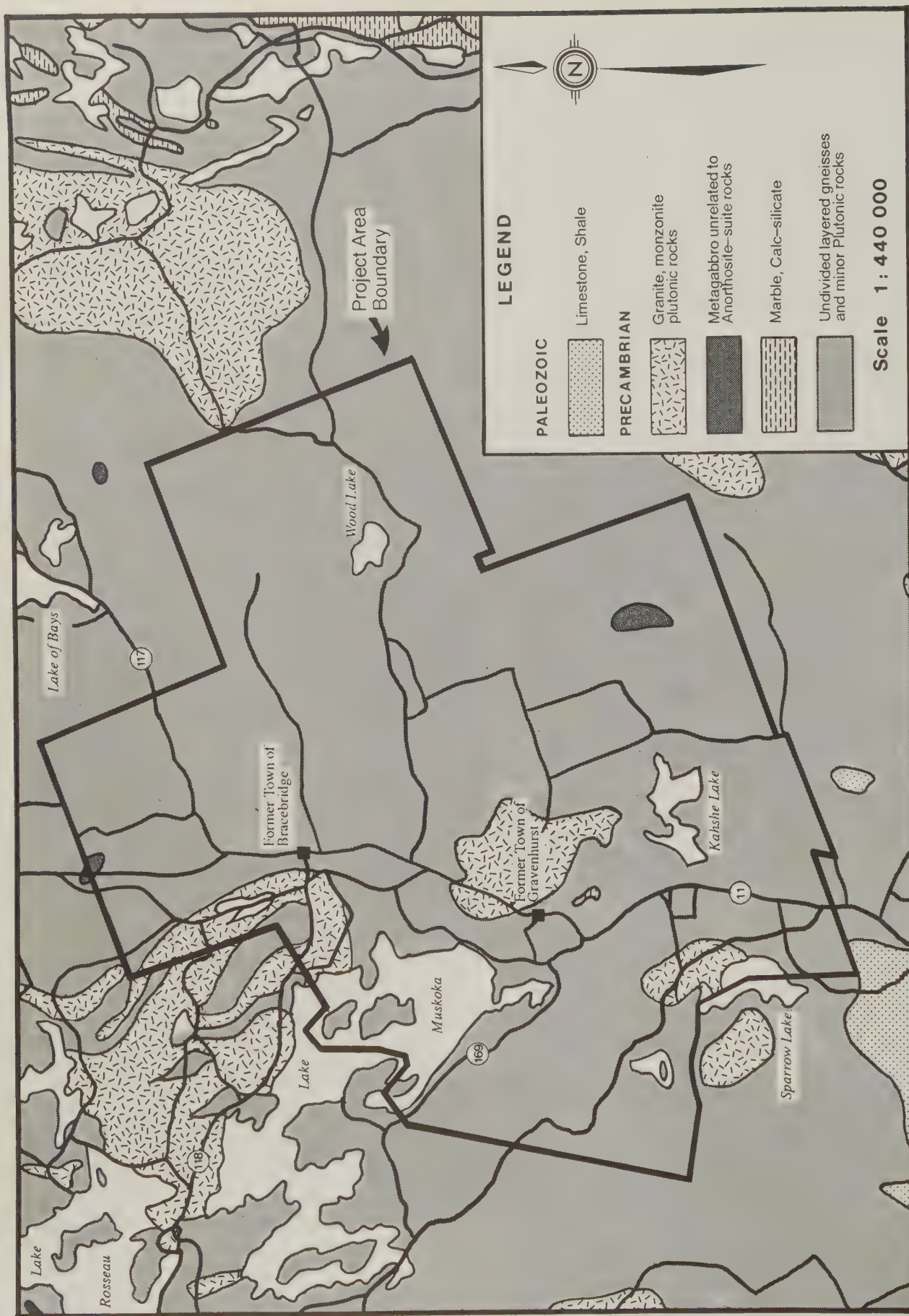


FIGURE 2: BEDROCK GEOLOGY OF THE TOWNS OF BRACEBRIDGE AND GRAVENHURST, Modified after Freeman (1979) and Schwerdtner and Waddington (1978).

Engineering and Terrain Geology Section, Ontario Geological Survey, Room M1B-45, Macdonald Block, Queen's Park, 900 Bay Street, Toronto, Ontario, M7A 1W4, [Tel: (416) 965-1663], or to the Resident Geologist, Algonquin District, Ministry of Northern Development and Mines, Box 190, Dorset, Ontario, P0A 1E0, [Tel: (705) 766-2494] or to the Bracebridge District, Ministry of Natural Resources, Box 1138, Bracebridge, Ontario, P0B 1C0, [Tel: (705) 645-8747].

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, TOWNS OF BRACEBRIDGE AND GRAVENHURST.*

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)	1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
TOWN OF BRACEBRIDGE				4	S-IC	18 (7)	< 1 (< 1)
Monck Geographic Township					S-LP	600 (243)	8 (7)
3	S-LP	560 (227)	14 (13)				
4	S-LP	390 (158)	5 (4)			5500 (2230)	189 (171)
		950 (385)	19 (17)	Draper Geographic Township			
				1	S-LD	60 (24)	3 (3)
Muskoka Geographic Township					S-OW	72 (29)	5 (4)
1	G-IC-LD	36 (15)	2 (2)	2	S-OW	60 (24)	2 (2)
2	G-OW	5 (2)	< 1 (< 1)	3	S-LD	182 (74)	3 (3)
	S-LD	13 (5)	< 1 (< 1)		S-LP	21 (8)	< 1 (< 1)
3	S-LD	48 (19)	1 (< 1)		S-OW	250 (101)	5 (4)
	S-OW	6 (2)	< 1 (< 1)	4	S-LD	13 (5)	< 1 (< 1)
4	S-LP	1530 (620)	19 (17)		S-LP	226 (92)	2 (2)
		1640 (660)	22 (20)		S-OW	750 (305)	10 (9)
Macaulay Geographic Township						1630 (660)	30 (27)
1	G-OW	450 (182)	34 (31)	Oakley Geographic Township			
	S-IC-LD	99 (40)	7 (6)	2	G-OW	84 (34)	3 (3)
	S-LD	107 (43)	8 (7)		S-OW	38 (15)	1 (< 1)
	S-LP	69 (28)	4 (4)	3	G-OW	45 (18)	< 1 (< 1)
	S-OW	1030 (415)	52 (47)		S-OW	420 (170)	7 (6)
2	G-LD	22 (9)	< 1 (< 1)	4	S-OW	1420 (570)	18 (16)
	S-IC	60 (24)	2 (2)			2010 (810)	29 (26)
	S-LP	1170 (475)	42 (38)	McLean Geographic Township			
3	G-IC	2 (1)	< 1 (< 1)	2	G-OW	160 (65)	6 (5)
	G-OW	157 (64)	3 (3)		S-OW	285 (115)	9 (8)
	S-IC	42 (17)	< 1 (< 1)	3	S-OW	65 (26)	< 1 (< 1)
	S-LP	1240 (500)	20 (18)	4	G-OW	24 (10)	< 1 (< 1)
	S-OW	480 (194)	9 (8)				

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, TOWNS OF BRACEBRIDGE AND GRAVENHURST.*

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)	1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
	S-OW	200 (81)	2 (2)		S-OW	180 (73)	2 (2)
		730 (295)	17 (15)			2480 (1000)	44 (40)
TOTAL FOR TOWN OF BRACEBRIDGE:				Morrison Geographic Township			
		12,500 (5100)	305 (275)	1	S-LD	48 (19)	3 (3)
TOWN OF GRAVENHURST				2	S-SF	770 (310)	26 (24)
Wood Geographic Township				3	S-OW	106 (43)	2 (2)
4	G-OW	33 (13)	< 1 (< 1)		S-SF	1000 (405)	20 (18)
	S-OW	124 (50)	1 (< 1)	4	G-OW	80 (32)	1 (< 1)
		157 (64)	1 (< 1)		S-LP	234 (95)	3 (3)
Muskoka Geographic Township					S-OW	176 (71)	2 (2)
1	G-IC-LD	11 (4)	< 1 (< 1)		S-SF	189 (76)	2 (2)
	G-OW	8 (3)	< 1 (< 1)				
2	G-E	11 (4)	< 1 (< 1)			2600 (1050)	59 (54)
	G-IC	5 (2)	< 1 (< 1)	Ryde Geographic Township			
	G-OW	43 (17)	1 (< 1)	2	G-OW	10 (4)	< 1 (< 1)
	S-LD	660 (265)	20 (18)		S-OW	90 (36)	3 (3)
3	G-E	6 (2)	< 1 (< 1)	3	G-OW	118 (48)	3 (3)
	G-IC	140 (57)	3 (3)		S-OW	640 (260)	15 (14)
	G-LD	17 (7)	< 1 (< 1)	4	G-OW	150 (61)	2 (2)
	G-OW	25 (10)	< 1 (< 1)		S-OW	990 (400)	12 (11)
	S-OW	790 (320)	12 (11)			2000 (810)	35 (32)
4	G-OW	11 (4)	< 1 (< 1)	TOTAL FOR TOWN OF GRAVENHURST:			
	S-LD	25 (10)	< 1 (< 1)			7200 (2900)	139 (126)
	S-LP	550 (223)	6 (5)	TOTAL FOR STUDY AREA:			
						19,700 (8000)	445 (405)

* Identified deposit areas within the former towns of Bracebridge and Gravenhurst and Bigwind Lake Provincial Park are omitted on all tables.

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 2. SAND AND GRAVEL PITS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 NO.	2 MTO NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
TOWN OF BRACEBRIDGE						
Monck Geographic Township						
1	—	4	8	10 (3)	0	sand, recent excavation
2	—	8	1	—	—	inaccessible
Muskoka Geographic Township						
3	—	2	13	<5 (<1.5)	0	partially overgrown, silty fine sand
4	—	5	10	—	—	inaccessible
5	G14-68	4	10	—	—	inaccessible
6	—	2	11	5 (1.5)	0	silty fine sand, partially overgrown
7	G14-8	4	10	20 (6)	30-60 variable	partially overgrown, lenses of fine to coarse crushable gravel
8	—	3	10	10 (3)	variable	overgrown, fine to coarse gravel located near surface, depleted, bedrock exposed in pit floor
9	—	4	10	20 (6)	30-60	coarse gravel concentrated near surface, recent excavation
10	—	3	10	10 (3)	—	overgrown, largely depleted
11	—	4	10	5-12 (1.5-4)	variable	overgrown, fine to coarse gravel located in lenses
Macaulay Geographic Township						
12	B17-8	2	11	5-8 (1.5-2)	0	sand, partially overgrown
13	—	11	12	5 (1.5)	0	sand, bedrock exposed in pit floor
14	—	12	12	5-8 (1.5-2)	0	sand, partially overgrown, bedrock exposed in pit face
15	—	7	11	<5 (<1.5)	<10	silty fine sand lenses
16	—	2	7	—	—	inaccessible
17	—	10	10	5-7 (1.5-2)	0	sand, partially overgrown
18	B17-30	18	12	12 (4)	40-70	recent excavation, fine to coarse crushable gravel
19	—	14	11	5-7 (1.5-2)	30-40 variable	partially overgrown, fine to coarse gravel
20	—	14	10	6 (1.8)	<10	fine gravel, partially overgrown
21	—	14	10	15-30 (5-9)	30-60	lenses of fine to coarse gravel, slumped faces
22	—	8	9	10-15 (3-5)	0	sand, partially overgrown
23	—	9	7	5-7 (1.5-2)	<10	partially overgrown, fine gravel and medium sand

TABLE 2. SAND AND GRAVEL PITS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 NO.	2 MTO NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
24	B17-37	11-12	7	20-40 (6-12)	variable	fine to coarse gravel concentrated near surface, lenses of silty fine sand
25	B17-37	11-12	7	15-30 (5-9)	0-50 variable	fine to coarse gravel concentrated near surface, silty fine sand lenses, worked in several faces
26	B17-11	10	6	10-25 (3-8)	variable	partially rehabilitated, overgrown, largely depleted, pockets of fine to coarse gravel
27	B17-97	8	6	< 5 (< 1.5)	0	fine sand, partially overgrown
28	B17-16	8	5	10-35 (3-11)	0-40	fine to coarse gravel concentrated near surface
29	-	9	5	5-8 (1.5-2)	0	sand, partially overgrown
30	-	8	5	20 (6)	-	overgrown, pockets of crushable gravel
31	-	8	4	30 (9)	< 10 variable	mainly sand with lenses of gravel
32	B17-13	8	4	25 (8)	0-40 variable	several faces, fine to coarse gravel located in lenses near surface, bedrock exposed in pit floor
33	-	8	3-4	10-30 (3-9)	0-50 variable	several faces, fine to coarse gravel occurs in lenses, partially overgrown, slumped faces, water on pit floor
34	B17-14	8	3-4	5-20 (1.5-6)	0-50 variable	fine to coarse gravel concentrated in lenses near surface
35	B17-34	8	3	5-8 (1.5-2)	variable	partially overgrown, fine to coarse gravel concentrated in lenses
36	-	10	3	10-20 (3-6)	< 20	gravel concentrated near surface
37	B17-60	9	3	8-10 (2-3)	30-50 variable	partially overgrown, fine to coarse gravel located in lenses, slumped face
38	-	10	3	10-20 (3-6)	0-50 variable	fine to coarse gravel concentrated near surface, slumped face
39	B17-42	10	3	10-30 (3-9)	variable	fine to coarse gravel located in pockets
40	B17-92	5	1	40-50 (12-15)	< 20 variable	bedrock exposed in pit face, fine to coarse gravel located in pockets, lenses of silty fine sand, largely depleted
41	-	16	6	-	-	inaccessible
42	-	19	7	-	-	inaccessible
43	-	19	7	-	-	inaccessible

TABLE 2. SAND AND GRAVEL PITS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 NO.	2 MTO NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
44	—	19	7	8–10 (2–3)	0–40 variable	bedrock exposed in pit face, fine gravel located in pockets, lenses of silty fine sand
45	—	27	12	5 (1.5)	< 20	overgrown, fine gravel, silty sand
46	—	25	9	—	—	inaccessible
47	—	25	8	5–12 (1.5–4)	0	sand, partially overgrown
48	—	28	2	5–6 (1.5–1.8)	—	till, overgrown
49	—	31	3	< 5 (< 1.5)	0	sand, overgrown, bedrock exposed in pit face
50	—	31	2	< 5 (< 1.5)	0	sand
51	—	30	2	10–15 (3–5)	0	sand, partially overgrown, bedrock exposed in pit face
Draper Geographic Township						
52	B17–7	4	13	5–8 (1.5–2)	—	overgrown, largely depleted
53	B17–7	4	13	5–8 (1.5–2)	variable	partially overgrown, largely depleted, bedrock exposed in pit floor
54	—	4	13	20–25 (6–8)	—	clay pit
55	B17–7	4	13	20–40 (6–12)	0–40 variable	worked in several levels, many faces, fine to coarse gravel concentrated in lenses, lenses of silt near surface
56	B17–111	4	13	20–45 (6–14)	0–40 variable	fine to coarse gravel concentrated in lenses, silty fine sand lenses, slumped face
57	—	3	11	20 (6)	0	sand, overgrown, bedrock exposed in pit face
58	—	1	9	< 5 (< 1.5)	0	sand, overgrown
59	—	17	13	—	—	inaccessible
60	—	17	13	6–8 (1.8–2)	—	till, partially overgrown
61	—	6	7	—	—	inaccessible
62	—	10	6	10 (3)	< 10	partially overgrown, bedrock exposed in pit face
63	—	A	1	5–8 (1.5–2)	0	silt, overgrown
64	—	6	3	10 (3)	< 10	partially overgrown
65	—	18	8	< 5 (< 1.5)	0	fine sand
66	—	29	9	—	—	inaccessible
67	—	29–30	9	5–6 (1.5–1.8)	0	sand, overgrown

TABLE 2. SAND AND GRAVEL PITS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 NO.	2 MTO NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
68	–	30	9	5–8 (1.5–2)	0	sand, partially overgrown
69	–	30	9	5–8 (1.5–2)	0	fine sand, partially overgrown
70	B17–75	31	10	5–8 (1.5–2)	< 10	partially overgrown, lenses of fine gravel, silty fine sand lenses
71	–	32	10	5–8 (1.5–2)	0	sand, partially overgrown
72	–	31	8	7 (2)	0–40 variable	partially overgrown, fine to coarse gravel located in lenses near surface, bedrock exposed in pit floor
73	–	31	7	5–10 (1.5–3)	0–40 variable	partially overgrown, fine to coarse gravel located in lenses, bedrock exposed in pit floor, largely depleted
74	–	30	7	5–15 (1.5–5)	0–30 variable	fine to coarse gravel located near surface, lenses of silt, bedrock and water present in pit floor, partially overgrown, largely depleted, slumped faces
75	–	30	7	10–20 (3–6)	variable	overgrown to partially overgrown, largely depleted, slumped faces
76	–	30	7	–	–	inaccessible
77	–	21	6	5–7 (1.5–2)	–	till, partially overgrown
78	–	21	5	< 5 (< 1.5)	–	till, overgrown
79	–	24	5	–	–	inaccessible
80	–	22	3	8 (2)	< 20	partially overgrown, slumped faces, gravel located in lenses
81	–	22	2	5–8 (1.5–2)	< 20	partially overgrown
82	–	24	2	10–20 (3–6)	< 30 variable	fine to coarse gravel concentrated near surface
83	–	21	1	–	–	inaccessible
McLean Geographic Township						
84	–	29	2	–	–	inaccessible
85	–	32	1	5–8 (1.5–2)	0	sand, partially overgrown, bedrock in pit face
86	–	29	1	5–7 (1.5–2)	0	sand, partially overgrown
87	–	25	1	5–6 (1.5–1.8)	30–50	fine to coarse crushable gravel located in lenses
88	–	26	1	10–15 (3–5)	30–50	partially overgrown, fine to coarse gravel occurs in lenses
89	–	26	1	10–15 (3–5)	30–50	fine to coarse gravel located near surface

TABLE 2. SAND AND GRAVEL PITS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 NO.	2 MTO NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
90	—	26	1	15 (5)	30–50 variable	fine to coarse gravel located near surface
91	—	27	1	10–15 (3–5)	10–30 variable	partially overgrown, slumped faces, fine to coarse gravel concentrated in lenses
Oakley Geographic Township						
92	—	31	14	—	—	inaccessible
93	—	28	13	5–10 (1.5–3)	< 10	partially overgrown
94	—	28	13	5–10 (1.5–3)	< 10	
95	—	23	14	< 5 (< 1.5)	0	sand, overgrown
96	—	30	11	—	—	inaccessible
97	—	16	10	5–10 (1.5–3)	—	till, recent excavation
98	—	1	12	5–8 (1.5–2)	30–50 variable	partially overgrown, fine to coarse gravel occurs in lenses
99	H2–59	4	9	10–15 (3–5)	0–50 variable	partially overgrown, slumped faces, fine to coarse gravel located in lenses, largely depleted
100	H2–66	4	9	10–15 (3–5)	< 20	partially rehabilitated, bedrock exposed in pit floor, partially overgrown, largely depleted
101	—	4	8	5–8 (1.5–2)	0–40 variable	partially overgrown, fine to coarse gravel lenses
102	—	4	7	10–20 (3–6)	0–40	lenses of silt and clay, oversize, fine to coarse gravel located in pockets near surface
103	—	6	6	5 (1.5)	< 10	partially overgrown
104	—	7	6	20 (6)	< 10	overgrown
105	—	8	6	10–20 (3–6)	< 10	overgrown to partially overgrown, bedrock exposed in pit face
106	—	16	6	5 (1.5)	0	sand, overgrown
107	—	23	5	< 5 (< 1.5)	0	sand, partially overgrown
108	—	24	6	5–10 (1.5–3)	variable	partially overgrown
109	—	25	6	5–12 (1.5–4)	< 10	partially overgrown, bedrock exposed in pit floor
110	—	26	6	< 5 (< 1.5)	0	sand, overgrown
111	—	28	6	—	—	inaccessible
112	—	22	3–4	< 5 (< 1.5)	0	sand, partially overgrown

TABLE 2. SAND AND GRAVEL PITS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 NO.	2 MTO NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
113	-	19	1	<5 (<1.5)	<20	partially overgrown, fine gravel located in pockets
114	-	18	1	6-12 (1.8-4)	<10	
TOWN OF GRAVENHURST						
Wood Geographic Township						
115	-	6	13	<5 (<1.5)	variable	overgrown, bedrock in pit floor
116	-	6	16	<5 (<1.5)	variable	partially overgrown, bedrock in pit floor
117	-	6	16	<5 (<1.5)	-	overgrown
118	-	6	16	5-8 (1.5-2)	<20 variable	overgrown
119	-	5	16	<5 (<1.5)	0	sand, partially overgrown
120	-	C	15	<5 (<1.5)	-	till, overgrown, bedrock exposed in pit faces
Muskoka Geographic Township						
121	G14-77	4	9	10-15 (3-5)	30-60 variable	overgrown, largely depleted
122	-	3	9	5-10 (1.5-3)	30-70	fine to coarse gravel
123	-	4	9	<5 (<1.5)	variable	overgrown, water on pit floor
124	-	7	8	5-10 (1.5-3)	<30 variable	partially overgrown
125	G14-22	7-8	8	8-10 (2-3)	20-30 variable	partially overgrown, some oversize, fine to coarse gravel lenses near surface, water on pit floor
126	-	3	7	8-10 (2-3)	30-40	gravel concentrated in upper levels of pit
127	-	10	7	5 (1.5)	30-40 variable	overgrown
128	G14-67	10	7	5-12 (1.5-4)	40-50 variable	overgrown, largely depleted
129	-	10	7	20-25 (6-8)	-	bedrock exposed in pit face
130	G14-32	10	7	20-25 (6-8)	20-50 variable	large pit, fine to coarse gravel concentrated in lenses, bedrock exposed in pit face, partially overgrown, water on pit floor, some oversize
131	-	10	6	<5 (<1.5)	30-40	overgrown
132	-	10	6	3-8 (1-2)	20-40	partially overgrown, graded, water on pit floor
133	-	10	6	5-10 (1.5-3)	variable	overgrown
134	G14-6	10	6	10-12 (3-4)	<20 variable	gravel occurs near surface, recent extraction

TABLE 2. SAND AND GRAVEL PITS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 NO.	2 MTO NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
135	—	8	7	5-8 (1.5-2)	< 20	partially overgrown, water on pit floor
136	—	6	6	5-7 (1.5-2)	0	sand, partially overgrown
137	—	4	6	5-8 (1.5-2)	< 20	partially overgrown, water on pit floor
138	—	17	7	< 5 (< 1.5)	variable	partially rehabilitated, graded
139	—	18	7	20-25 (6-8)	30-50 variable	crushable gravel occurs in lenses, partially overgrown
140	—	20	6	10-12 (3-4)	30-50 variable	clay in pit floor
141	—	17	6	—	—	rehabilitated and graded
142	G14-74	17	6	10-15 (3-5)	< 20	gravel occurs in lenses
143	—	17	5	5-10 (1.5-3)	< 20 variable	overgrown, gravel occurs in lenses
144	—	20	6	5-8 (1.5-2)	20 variable	overgrown
145	G14-23	19-20	5	5-20 (1.5-6)	variable	large pit, worked in several levels, bedrock exposed in pit floor, partially overgrown, largely depleted
146	G14-59	20	5	10-20 (3-6)	30-50 variable	partially overgrown, lenses of silt
147	G14-02	18	5	10-15 (3-5)	variable	overgrown, water on pit floor, gravel occurs in lenses
148	G14-03	16-17	5	10-30 (3-9)	< 20 variable	partially rehabilitated, graded, bedrock in pit face
149	—	16	4	< 5 (< 1.5)	—	till
150	—	4	Range East	< 5 (< 1.5)	—	overgrown
151	—	3	Range West	—	—	inaccessible
152	G14-73	2	Range East	6-9 (1.8-3)	variable	sloughed faces
153	G14-73	2	Range East	6 (1.8)	variable	sloughed faces
Morrison Geographic Township						
154	—	31	12	—	—	inaccessible
155	—	30	12	< 5 (< 1.5)	30-40	partially overgrown
156	—	29	11	—	—	inaccessible
157	—	29	11	—	variable	overgrown, waterfilled
158	—	35	Range East	10 (3)	< 10	gravel occurs near surface
159	G14-15	32	Range West	5-12 (1.5-4)	20-30 variable	partially overgrown, water on pit floor, bedrock in pit face, gravel concentrated near surface
160	—	29	Range West	5-8 (1.5-2)	variable	overgrown, gravel occurs in pockets

TABLE 2. SAND AND GRAVEL PITS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 NO.	2 MTO NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
161	–	28	Range West	5–10 (1.5–3)	–	sand flanks bedrock exposed in pit
162	G14–30	29	Range West	10–20 (3–6)	30–40 variable	partially overgrown, material gets coarser with depth, fine to coarse gravel located in lower sections of pit
163	–	29	Range West	15 (5)	< 10	partially overgrown, lenses of silty fine sand
164	–	27	Range West	< 5 (< 1.5)	30–40	partially overgrown
165	G14–36	27	Range West	8–10 (2–3)	30–50 variable	partially overgrown, bedrock exposed in pit face
166	G14–56	27	Range West	20–25 (6–8)	10–20 variable	pit used as dump, fine gravel occurs in lenses, silty fine sand sections
167	G14–85	26	Range West	20–25 (6–8)	30–40 variable	partially overgrown, bedrock exposed in pit face, gravel concentrated in lenses in lower sections of pit
168	G14–65	26	Range West	15–20 (5–6)	< 20 variable	bedrock exposed in pit face, partially overgrown
169	G14–55	26	Range West	10–20 (3–6)	variable	overgrown, largely depleted
170	G14–76	23	Range West	5–12 (1.5–4)	0–50 variable	partially overgrown, gravel occurs in pockets, bedrock exposed in pit floor
171	–	18	8	5–8 (1.5–2)	< 20	overgrown, mainly sand
172	–	18	Range West	< 5 (< 1.5)	variable	overgrown
173	–	18	Range West	5–8 (1.5–2)	< 20 variable	overgrown, water on pit floor
174	–	16	Range West	5–10 (1.5–3)	< 10	partially overgrown, gravel occurs in lenses
175	G14–17	16	Range West	10–15 (3–5)	variable	partially overgrown, graded faces, bedrock exposed in pit floor, largely depleted
176	G14–70	13	Range West	10–20 (3–6)	< 10	partially overgrown
177	G14–70	12	Range West	10–15 (3–5)	< 30 variable	partially overgrown
178	G14–18	11	Range West	20 (6)	< 30 variable	overgrown, gravel occurs in pockets
179	G14–10	10	Range West	5–15 (1.5–5)	0–50 variable	recent extraction, fine to coarse gravel concentrated in lenses in lower sections of pit, silty fine sandy sections
180	–	26	4	–	–	rehabilitated

TABLE 2. SAND AND GRAVEL PITS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 NO.	2 MTO NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
181	G14-16	8	Range West	5-12 (1.5-4)	< 20 variable	overgrown, largely depleted, bedrock exposed in pit floor, largely depleted, lenses of silty fine sand
182	G14-21	7	Range West	5-15 (1.5-5)	variable	overgrown, bedrock exposed in pit face, largely depleted
183	G14-27	5-6	Range West	5-15 (1.5-5)	variable	
184	G14-29	5	Range West	5-10 (1.5-3)	0-50 variable	partially overgrown, bedrock exposed in pit floor, gravel concentrated in pockets
185	-	5	Range West	5-8 (1.5-2)	< 30 variable	partially overgrown, gravel occurs in pockets
186	G14-58	25	2	-	-	waterfilled, overgrown
187	G14-89	3	Range West	< 5 (< 1.5)	< 10	overgrown, mainly sand with occasional gravel pockets
188	-	26	1	< 5 (< 1.5)	0	sand, overgrown
189	-	27	1	5-8 (1.5-2)	< 10	fine gravel lenses near surface
190	G14-60	27-28	1	5-12 (1.5-4)	0-50 variable	overgrown, gravel occurs in pockets
191	-	6	A	< 5 (< 1.5)	< 20 variable	partially overgrown
192	-	6	A	< 5 (< 1.5)	< 20 variable	overgrown, bedrock exposed in pit floor
193	G14-61	6	1	5-7 (1.5-2)	< 30 variable	partially overgrown, fine to coarse gravel occurs in lenses, water on pit floor
194	-	5	1	< 5 (< 1.5)	20-30 variable	partially overgrown, water on pit floor, gravel occurs in lenses
195	-	1	A	5-10 (1.5-3)	< 10	partially overgrown, largely fine to medium sand with minor amounts of fine gravel, silty fine sand sections
Ryde Geographic Township						
196	-	30	1	5-10 (1.5-3)	30-50 variable	partially overgrown, bedrock exposed in pit faces, water on pit floor
197	-	28	4	10-15 (3-5)	30-60 variable	partially overgrown, bedrock exposed in pit face
198	-	28	5	5-15 (1.5-5)	40-60 variable	partially overgrown, bedrock exposed in pit face, water on pit floor, largely depleted
199	-	27	5	5-6 (1.5-1.8)	-	overgrown, rehabilitated, bedrock exposed in pit floor, largely depleted

TABLE 2. SAND AND GRAVEL PITS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 NO.	2 MTO NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
200	-	26	6	<5 (<1.5)	variable	overgrown
201	-	25	6	5-10 (1.5-3)	0-60 variable	partially overgrown, bedrock exposed in pit floor, fine to coarse gravel occurs in pockets
202	-	25	6	5-15 (1.5-5)	30-50 variable	partially overgrown, dragline operation, fine to coarse gravel occurs in lenses
203	-	24	7	5-10 (1.5-3)	<20	partially overgrown, water in pit floor, largely medium sand with minor fine gravel
204	-	19	8	5-15 (1.5-5)	<30 variable	partially overgrown, bedrock exposed in pit floor, gravel concentrated in upper section of pit
205	G14-42	18	8	5-10 (1.5-3)	<30 variable	partially overgrown, gravel occurs in pockets
206	-	18	8	5-10 (1.5-3)	20	partially overgrown, bedrock exposed in pit floor
207	G14-41	15	10	10-15 (3-5)	variable	overgrown, gravel occurs in pockets
208	-	14	11	5-8 (1.5-2)	30-50 variable	partially overgrown, bedrock exposed in pit floor, largely depleted, gravel occurs in lenses
209	-	13	11	-	-	inaccessible
210	-	11	12	8-12 (2-4)	0	sand, partially overgrown, silty fine sand lenses
211	-	10	12	<5 (<1.5)	variable	overgrown, gravel concentrated in lenses
212	-	11	12	5-10 (1.5-3)	0-50 variable	partially overgrown, fine to coarse gravel concentrated in upper 5 feet (1.5 m)
213	G14-39	10	12	5-10 (1.5-3)	30-60 variable	partially overgrown, water on pit floor, bedrock exposed in pit floor, coarse gravel concentrated near surface
214	-	7	11	5-8 (1.5-2)	0	sand, bedrock in pit faces
215	-	6	5	<5 (<1.5)	30-40	partially overgrown
216	-	6	5	5-7 (1.5-2)	30-50	partially overgrown
217	-	6	4	5 (1.5)	30-50 variable	partially overgrown, gravel occurs in lenses

TABLE 3. SELECTED SAND AND GRAVEL RESOURCE AREAS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 DEPOSIT NO.	2 UNLICENCED AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE ¹ AGGREGATE Millions of Tons (Tonnes)
TOWN OF BRACEBRIDGE						
1	450 (182)	40 (16)	20 (8)	390 (158)	30 (9)	29.2 (26.5)
2	22 (9)	6 (2)	5 (2)	11 (4)	12 (4)	0.3 (0.3)
3	670 (270)	230 (93)	130 (53)	310 (125)	20 (6)	15.5 (14.1)
4	36 (15)	15 (6)	15 (6)	6 (2)	20 (6)	0.3 (0.3)
5	5 (2)	0 (0)	0 (0)	5 (2)	10 (3)	0.1 (< 0.1)
6	75 (30)	15 (6)	30 (12)	30 (12)	30 (9)	2.2 (2.0)
7	160 (65)	10 (4)	20 (8)	130 (53)	15 (5)	4.9 (4.4)
8	80 (32)	10 (4)	5 (2)	65 (26)	15 (5)	2.4 (2.2)
TOTAL FOR THE TOWN OF BRACEBRIDGE:						
	1500 (610)	325 (132)	225 (91)	950 (385)		54.9 (49.8)
TOWN OF GRAVENHURST						
9	43 (17)	30 (12)	5 (2)	8 (3)	10 (3)	0.2 (0.2)
10	11 (4)	5 (2)	5 (2)	1 (< 1)	20 (6)	< 0.1 (< 0.1)
11	11 (4)	2 (1)	5 (2)	4 (2)	15 (5)	0.2 (0.2)
12a	8 (3)	0 (0)	6 (2)	2 (1)	20 (6)	0.1 (< 0.1)
12b	25 (10)	0 (0)	10 (4)	15 (6)	8 (2)	0.3 (0.3)
	33 (13)	0 (0)	16 (6)	17 (7)		0.4 (0.4)
13a	190 (77)	65 (26)	35 (14)	90 (36)	15 (5)	3.4 (3.1)
13b	670 (270)	260 (105)	30 (12)	380 (154)	8 (2)	7.6 (6.9)
13c	200 (81)	65 (26)	10 (4)	125 (51)	15 (5)	4.7 (4.3)
	1060 (430)	390 (158)	75 (30)	600 (243)		15.7 (14.2)
14a	50 (20)	5 (2)	20 (8)	25 (10)	8 (2)	0.5 (0.4)
14b	28 (11)	5 (2)	5 (2)	18 (7)	8 (2)	0.4 (0.4)
14c	10 (4)	1 (< 1)	5 (2)	4 (2)	15 (5)	0.2 (0.2)
14d	30 (12)	15 (6)	10 (4)	5 (2)	10 (3)	0.1 (< 0.1)
	118 (48)	26 (11)	40 (16)	52 (21)		1.2 (1.1)

TABLE 3. SELECTED SAND AND GRAVEL RESOURCE AREAS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

1 DEPOSIT NO.	2 UNLICENCED AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE ¹ AGGREGATE Millions of Tons (Tonnes)
TOTAL FOR THE TOWN OF GRAVENHURST:						
	1280 (520)	455 (184)	146 (59)	680 (275)		17.7 (16.0)
TOTAL FOR THE REPORT AREA:						
	2800 (1130)	780 (315)	370 (150)	1630 (660)		72.6 (65.9)

¹For practical purposes, the Available Aggregate figures for this report area have been shown to the nearest decimal place, because of the limited amounts of material present in some of the resource areas.

TABLE 4. SUMMARY OF TEST HOLE DATA, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

TOWN OF BRACEBRIDGE**Test Hole Number:** MU-TH-1**Location:** Macaulay Geographic Township
Lot 14, Concession 10**Elevation:** Approximately 980 feet (300 m) a.s.l.**Date:** October 6, 1988

Depth feet (metres)	Description
0-12.0 (0-3.6)	fine to coarse gravel; minor iron staining

Test Hole Number: MU-TH-2**Location:** Macaulay Geographic Township
Lot 13, Concession 9**Elevation:** Approximately 980 feet (300 m) a.s.l.**Date:** October 6, 1988

Depth feet (metres)	Description
0-11.0 (0-3.3)	fine to coarse gravel with clean coarse sand
11.0-14.0 (3.3-4.3)	silty fine sand

Test Hole Number: MU-TH-3**Location:** Macaulay Geographic Township
Lot 13, Concession 9**Elevation:** Approximately 1000 feet (305 m) a.s.l.**Date:** October 6, 1988

Depth feet (metres)	Description
0-13.0 (0-4.0)	fine to coarse gravel with clean medium to coarse sand

Test Hole Number: MU-TH-4**Location:** Macaulay Geographic Township
Lot 14, Concession 9**Elevation:** Approximately 1040 feet (315 m) a.s.l.**Date:** October 6, 1988

Depth feet (metres)	Description
0-3.0 (0-0.9)	fine sand
3.0-5.0 (0.9-1.5)	fine to coarse gravel
5.0-10.0 (1.5-3.0)	fine sand

TABLE 5. SUMMARY OF GEOPHYSICS DATA, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

TOWN OF BRACEBRIDGE**Line Number:** MU-GT-1**Line Direction:** North-South**Method:** Hammer Seismic**Location:** Macaulay Geographic Township
Lot 10, Concession 9**Elevation:** Approximately 990 feet (300 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1070$ ft/sec (325 m/sec)
 $V_2 = 1700$ ft/sec (520 m/sec)
 $V_3 = 6000$ ft/sec (1830 m/sec)
 Layer Thickness: $D_1 = 5$ ft (1.5 m)
 $D_2 = 27$ ft (8.2 m)

Interpretation: Approximately 5 feet (1.5 m) of loose sand over 27 feet (8.2 m) of sand and gravel over wet sand and gravel.**Line Number:** MU-GT-2**Line Direction:** North-South**Method:** Hammer Seismic**Location:** Macaulay Geographic Township
Lot 11, Concession 9**Elevation:** Approximately 930 feet (285 m) a.s.l.**Seismic Data:**

Number of Layers: 2
 Layer Velocities: $V_1 = 1200$ ft/sec (365 m/sec)
 $V_2 = 5800$ ft/sec (1770 m/sec)
 Layer Thickness: $D_1 = 11$ ft (3.4 m)

Interpretation: Approximately 11 feet (3.4 m) of sand and gravel over a minimum of 22 feet (6.7 m) of wet sand and gravel.**Line Number:** MU-GT-3**Line Direction:** North-South**Method:** Hammer Seismic**Location:** Macaulay Geographic Township
Lot 3, Concession 6**Elevation:** Approximately 850 feet (260 m) a.s.l.**Seismic Data:**

Number of Layers: 2
 Layer Velocities: $V_1 = 1970$ ft/sec (600 m/sec)
 $V_2 = 13,800$ ft/sec (4200 m/sec)
 Layer Thickness: $D_1 = 15$ ft (4.6 m)

Interpretation: Approximately 15 feet (4.6 m) of sand over bedrock.**Line Number:** MU-GT-4**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Macaulay Geographic Township
Lot 14, Concession 11**Elevation:** Approximately 1000 feet (305 m) a.s.l.**Seismic Data:**

Number of Layers: 2
 Layer Velocities: $V_1 = 1080$ ft/sec (330 m/sec)
 $V_2 = 2080$ ft/sec (630 m/sec)
 Layer Thickness: $D_1 = 15$ ft (4.6 m)

Interpretation: Approximately 15 feet (4.6 m) of loose sand and gravel over a minimum of 18 feet (5.5 m) of denser sand and gravel.**Line Number:** MU-GT-5**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Macaulay Geographic Township
Lot 14, Concession 10**Elevation:** Approximately 980 feet (300 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1050$ ft/sec (320 m/sec)
 $V_2 = 1910$ ft/sec (580 m/sec)
 $V_3 = 5300$ ft/sec (1620 m/sec)
 Layer Thickness: $D_1 = 4$ ft (1.2 m)
 $D_2 = 22$ ft (6.7 m)

Interpretation: Approximately 4 feet (1.2 m) of loose sand and gravel over 22 feet (6.7 m) of denser sand and gravel over a minimum of 7 feet (2.1 m) of wet sand and gravel.**Line Number:** MU-GT-6**Line Direction:** North-South**Method:** Hammer Seismic**Location:** Macaulay Geographic Township
Lot 12, Concession 9**Elevation:** Approximately 975 feet (295 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1160$ ft/sec (355 m/sec)
 $V_2 = 1760$ ft/sec (540 m/sec)
 $V_3 = 3400$ ft/sec (1040 m/sec)
 Layer Thickness: $D_1 = 10$ ft (3.0 m)
 $D_2 = 15$ ft (4.6 m)

Interpretation: Approximately 10 feet (3.0 m) of sand and gravel over 15 feet (4.6 m) of denser sand and gravel over a minimum of 8 feet (2.4 m) of denser gravel.**Line Number:** MU-GT-7**Line Direction:** North-South**Method:** Hammer Seismic**Location:** Macaulay Geographic Township
Lot 13, Concession 9**Elevation:** Approximately 1000 feet (305 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1170$ ft/sec (355 m/sec)
 $V_2 = 2400$ ft/sec (730 m/sec)
 $V_3 = 9300$ ft/sec (2850 m/sec)
 Layer Thickness: $D_1 = 7$ ft (2.1 m)
 $D_2 = 23$ ft (7.0 m)

Interpretation: Approximately 7 feet (2.1 m) of loose sand and gravel over 23 feet (7.0 m) of denser sand and gravel over an irregular surface of bedrock.**Line Number:** MU-GT-8**Line Direction:** North-South**Method:** Hammer Seismic**Location:** Macaulay Geographic Township
Lot 8, Concession 3**Elevation:** Approximately 1000 feet (305 m) a.s.l.**Seismic Data:**

Number of Layers: 2
 Layer Velocities: $V_1 = 1220$ ft/sec (370 m/sec)
 $V_2 = 2290$ ft/sec (700 m/sec)
 Layer Thickness: $D_1 = 8$ ft (2.4 m)

Interpretation: Approximately 8 feet (2.4 m) of loose sand and gravel over a minimum of 25 feet (7.6 m) of denser sand and gravel.

TABLE 5. SUMMARY OF GEOPHYSICS DATA, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

Line Number: MU-GT-9**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Draper Geographic Township
Lots 17 and 18, Concession 1**Elevation:** Approximately 940 feet (285 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1180 \text{ ft/sec (360 m/sec)}$
 $V_2 = 5000 \text{ ft/sec (1520 m/sec)}$
 $V_3 = 5300 \text{ ft/sec (1620 m/sec)}$
 Layer Thickness: $D_1 = 5 \text{ ft (1.5 m)}$
 $D_2 = 9 \text{ ft (2.7 m)}$

Interpretation: Approximately 5 feet (1.5 m) of sand and gravel over 9 feet (2.7 m) of denser sand and gravel over wet sand and gravel.**Line Number:** MU-GT-10**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Draper Geographic Township
Lot 22, Concession 2**Elevation:** Approximately 940 feet (285 m) a.s.l.**Seismic Data:**

Number of Layers: 2
 Layer Velocities: $V_1 = 1180 \text{ ft/sec (360 m/sec)}$
 $V_2 = 2200 \text{ ft/sec (670 m/sec)}$
 Layer Thickness: $D_1 = 10 \text{ ft (3.0 m)}$

Interpretation: Approximately 10 feet (3.0) of loose sand and gravel over a minimum of 23 feet (7.0 m) of denser sand and gravel.**Line Number:** MU-GT-11**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Oakley Geographic Township
Lot 3, Concession 9**Elevation:** Approximately 1040 feet (315 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1270 \text{ ft/sec (385 m/sec)}$
 $V_2 = 1510 \text{ ft/sec (460 m/sec)}$
 $V_3 = 5100 \text{ ft/sec (1550 m/sec)}$
 Layer Thickness: $D_1 = 5 \text{ ft (1.5 m)}$
 $D_2 = 21 \text{ ft (6.4 m)}$

Interpretation: Approximately 5 feet (1.5 m) of sand and gravel over 21 feet (6.4 m) of denser sand and gravel over wet sand and gravel.**Line Number:** MU-GT-12**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Oakley Geographic Township
Lot 19, Concession 1**Elevation:** Approximately 1000 feet (305 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1270 \text{ ft/sec (385 m/sec)}$
 $V_2 = 1750 \text{ ft/sec (530 m/sec)}$
 $V_3 = 3300 \text{ ft/sec (1010 m/sec)}$
 Layer Thickness: $D_1 = 4 \text{ ft (1.2 m)}$
 $D_2 = 22 \text{ ft (6.7 m)}$

Interpretation: Approximately 4 feet (1.2 m) of sand and gravel over a minimum of 22 feet (6.7 m) of dense sand and gravel.**TOWN OF GRAVENHURST****Line Number:** MU-GT-13**Line Direction:** Northeast-Southwest**Method:** Hammer Seismic**Location:** Muskoka Geographic Township
Lot 3, Concession 9**Elevation:** Approximately 900 feet (275 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1310 \text{ ft/sec (400 m/sec)}$
 $V_2 = 2140 \text{ ft/sec (650 m/sec)}$
 $V_3 = 4550 \text{ ft/sec (1390 m/sec)}$
 Layer Thickness: $D_1 = 3 \text{ ft (0.9 m)}$
 $D_2 = 18 \text{ ft (5.5 m)}$

Interpretation: Approximately 3 feet (0.9 m) of sand and gravel over 18 feet (5.5 m) of denser sand and gravel over wet sand and gravel.**Line Number:** MU-GT-14**Line Direction:** North-South**Method:** Hammer Seismic**Location:** Muskoka Geographic Township
Lot 2, Concession 9**Elevation:** Approximately 900 feet (275 m) a.s.l.**Seismic Data:**

Number of Layers: 2
 Layer Velocities: $V_1 = 1140 \text{ ft/sec (345 m/sec)}$
 $V_2 = 5700 \text{ ft/sec (1740 m/sec)}$
 Layer Thickness: $D_1 = 10 \text{ ft (3.0 m)}$

Interpretation: Approximately 10 feet (3.0 m) of loose sand and gravel over a minimum of 23 feet (7.0 m) of wet sand and gravel.**Line Number:** MU-GT-15**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Muskoka Geographic Township
Lot 2, Concession 7**Elevation:** Approximately 900 feet (275 m) a.s.l.**Seismic Data:**

Number of Layers: 2
 Layer Velocities: $V_1 = 1330 \text{ ft/sec (405 m/sec)}$
 $V_2 = 5700 \text{ ft/sec (1740 m/sec)}$
 Layer Thickness: $D_1 = 11 \text{ ft (3.4 m)}$

Interpretation: Approximately 11 feet (3.4 m) of loose sand and gravel over a minimum of 22 feet (6.7 m) of wet sand and gravel.**Line Number:** MU-GT-16**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Muskoka Geographic Township
Lot 10, Concession 6**Elevation:** Approximately 860 feet (260 m) a.s.l.**Seismic Data:**

Number of Layers: 2
 Layer Velocities: $V_1 = 1180 \text{ ft/sec (360 m/sec)}$
 $V_2 = 2600 \text{ ft/sec (790 m/sec)}$
 Layer Thickness: $D_1 = 9 \text{ ft (2.7 m)}$

Interpretation: Approximately 9 feet (2.7 m) of sand and gravel over denser sand and gravel.

TABLE 5. SUMMARY OF GEOPHYSICS DATA, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

Line Number: MU-GT-17**Line Direction:** Northeast-Southwest**Method:** Hammer Seismic**Location:** Muskoka Geographic Township
Lot 10, Concession 6**Elevation:** Approximately 850 feet (260 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1170$ ft/sec (355 m/sec)
 $V_2 = 2000$ ft/sec (610 m/sec)
 $V_3 = 16,000$ ft/sec (4900 m/sec)
 Layer Thickness: $D_1 = 7$ ft (2.1 m)
 $D_2 = 26$ ft (7.9 m)

Interpretation: Approximately 7 feet (2.1 m) of loose sand and gravel over a minimum of 26 feet (7.9 m) of denser sand and gravel.**Line Number:** MU-GT-18**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Muskoka Geographic Township
Lot 4, Concession 7**Elevation:** Approximately 900 feet (275 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1180$ ft/sec (360 m/sec)
 $V_2 = 5700$ ft/sec (1740 m/sec)
 $V_3 = 10,200$ ft/sec (3100 m/sec)
 Layer Thickness: $D_1 = 7$ ft (2.1 m)
 $D_2 = 23$ ft (7.0 m)

Interpretation: Approximately 7 feet (2.1 m) of sand and gravel over 23 feet (7.0 m) of wet sand and gravel over bedrock.**Line Number:** MU-GT-19**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Muskoka Geographic Township
Lot 4, Range West**Elevation:** Approximately 850 feet (260 m) a.s.l.**Seismic Data:**

Number of Layers: 2
 Layer Velocities: $V_1 = 1200$ ft/sec (365 m/sec)
 $V_2 = 4750$ ft/sec (1450 m/sec)
 Layer Thickness: $D_1 = 8$ ft (2.4 m)

Interpretation: Approximately 8 feet (2.4 m) of loose sand and gravel over a minimum of 25 feet (7.6 m) of wet sand and gravel.**Line Number:** MU-GT-20**Line Direction:** Northwest-Southeast**Method:** Hammer Seismic**Location:** Morrison Geographic Township
Lot 29, Range West**Elevation:** Approximately 830 feet (255 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1240$ ft/sec (380 m/sec)
 $V_2 = 1830$ ft/sec (560 m/sec)
 $V_3 = 10,000$ ft/sec (3050 m/sec)
 Layer Thickness: $D_1 = 9$ ft (2.7 m)
 $D_2 = 27$ ft (8.2 m)

Interpretation: Approximately 9 feet (2.7 m) of loose sand and gravel over a minimum of 27 feet (8.2 m) of denser sand and gravel.**Line Number:** MU-GT-21**Line Direction:** Northeast-Southwest**Method:** Hammer Seismic**Location:** Morrison Geographic Township
Lots 27 and 28, Range West**Elevation:** Approximately 830 feet (255 m) a.s.l.**Seismic Data:**

Number of Layers: 3
 Layer Velocities: $V_1 = 1250$ ft/sec (380 m/sec)
 $V_2 = 1910$ ft/sec (580 m/sec)
 $V_3 = 3400$ ft/sec (1040 m/sec)
 Layer Thickness: $D_1 = 5$ ft (1.5 m)
 $D_2 = 17$ ft (5.2 m)

Interpretation: Approximately 5 feet (1.5 m) of sand and gravel over a minimum of 17 feet (5.2 m) of denser sand and gravel.**Line Number:** MU-GT-22**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Morrison Geographic Township
Lot 18, Range West**Elevation:** Approximately 830 feet (255 m) a.s.l.**Seismic Data:**

Number of Layers: 2
 Layer Velocities: $V_1 = 1210$ ft/sec (370 m/sec)
 $V_2 = 9200$ ft/sec (2800 m/sec)
 Layer Thickness: $D_1 = 9$ ft (2.7 m)

Interpretation: Approximately 9 feet (2.7 m) of sand and gravel over an irregular bedrock surface.**Line Number:** MU-GT-23**Line Direction:** East-West**Method:** Hammer Seismic**Location:** Morrison Geographic Township
Lot 11, Range West**Elevation:** Approximately 750 feet (230 m) a.s.l.**Seismic Data:**

Number of Layers: 2
 Layer Velocities: $V_1 = 1410$ ft/sec (430 m/sec)
 $V_2 = 3600$ ft/sec (1100 m/sec)
 Layer Thickness: $D_1 = 16$ ft (4.9 m)

Interpretation: Approximately 16 feet (4.9 m) of sand and gravel over denser sand and gravel.

TABLE 6. RESULTS OF AGGREGATE QUALITY TESTS, TOWNS OF BRACEBRIDGE AND GRAVENHURST.

COARSE AGGREGATE						FINE AGGREGATE
Pit No.	Petrographic Number		Magnesium Sulphate Soundness % Loss	Absorption %	Los Angeles Abrasion % Loss	Magnesium Sulphate Soundness % Loss
	GBC & 16 mm Crushed	Hot Mix & Concrete				
TOWN OF BRACEBRIDGE						
9	110	178	—	—	—	—
18	116	208	—	—	—	—
21	116	211	—	—	—	—
24	109	173	—	—	—	—
32	113	193	—	—	—	—
37	108	174	—	—	—	—
88	112	194	—	—	—	—
TOWN OF GRAVENHURST						
122	118	199	—	—	—	—
146	118	199	—	—	—	—
170	109	181	—	—	—	—
179	111	182	—	—	—	—
202	103	167	—	—	—	—
216	113	201	—	—	—	—

NOTE: The quality refers strictly to a specific sample taken at the time of field investigation. Because of the inherent variability of sand and gravel deposits, care should be exercised in extrapolating such information to the rest of the deposit.

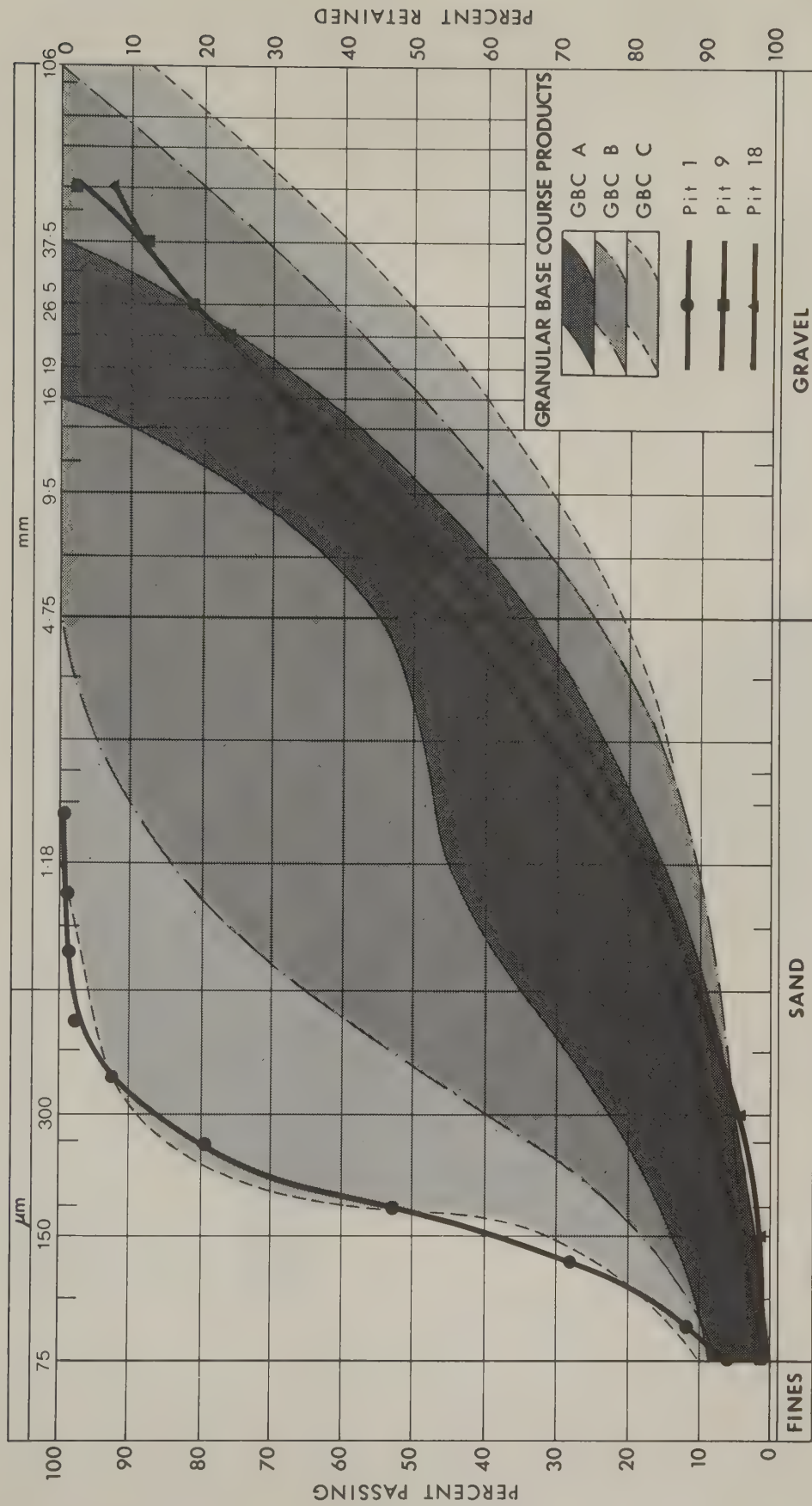


FIGURE 3a: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

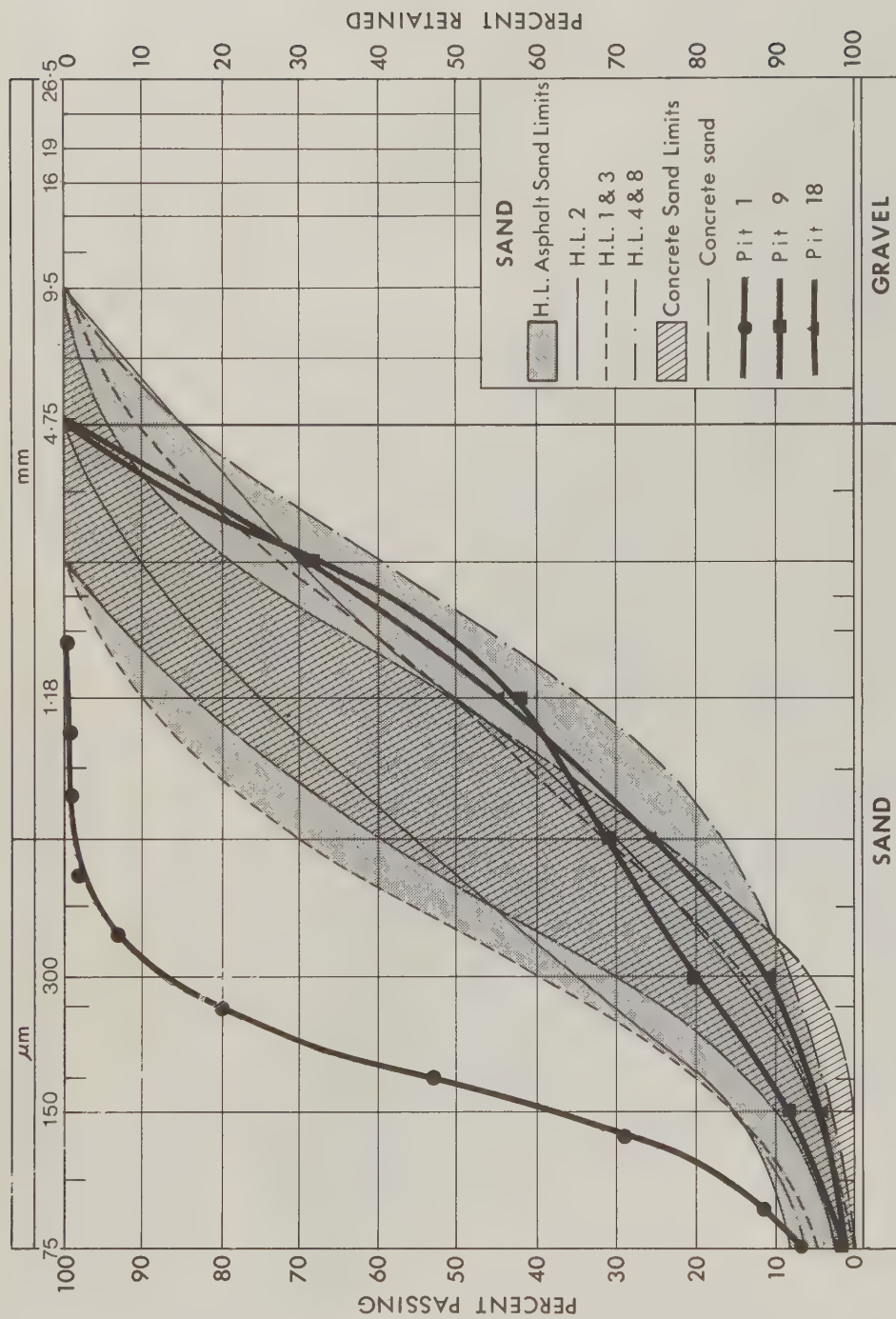


FIGURE 3b: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

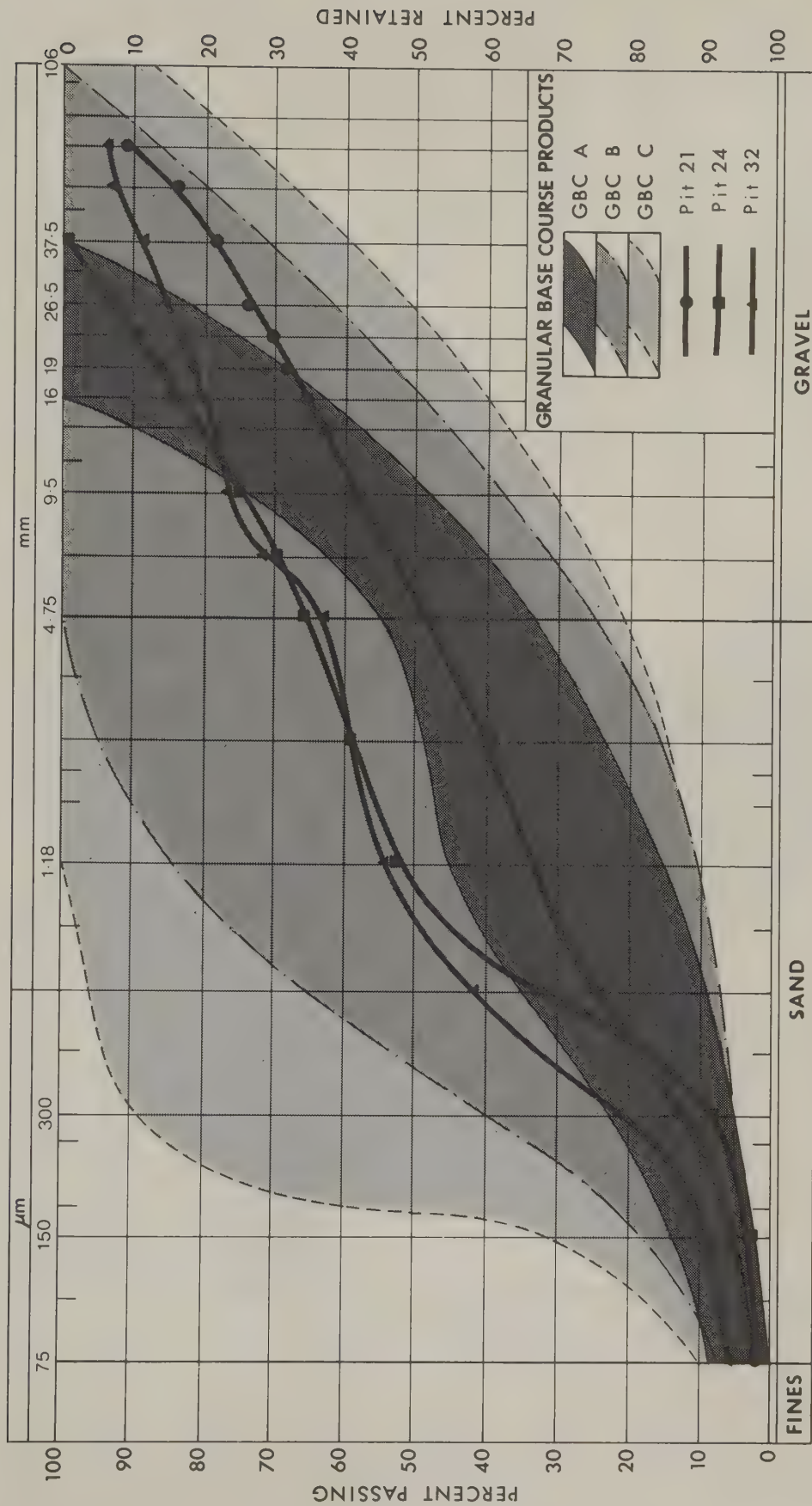


FIGURE 4a: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

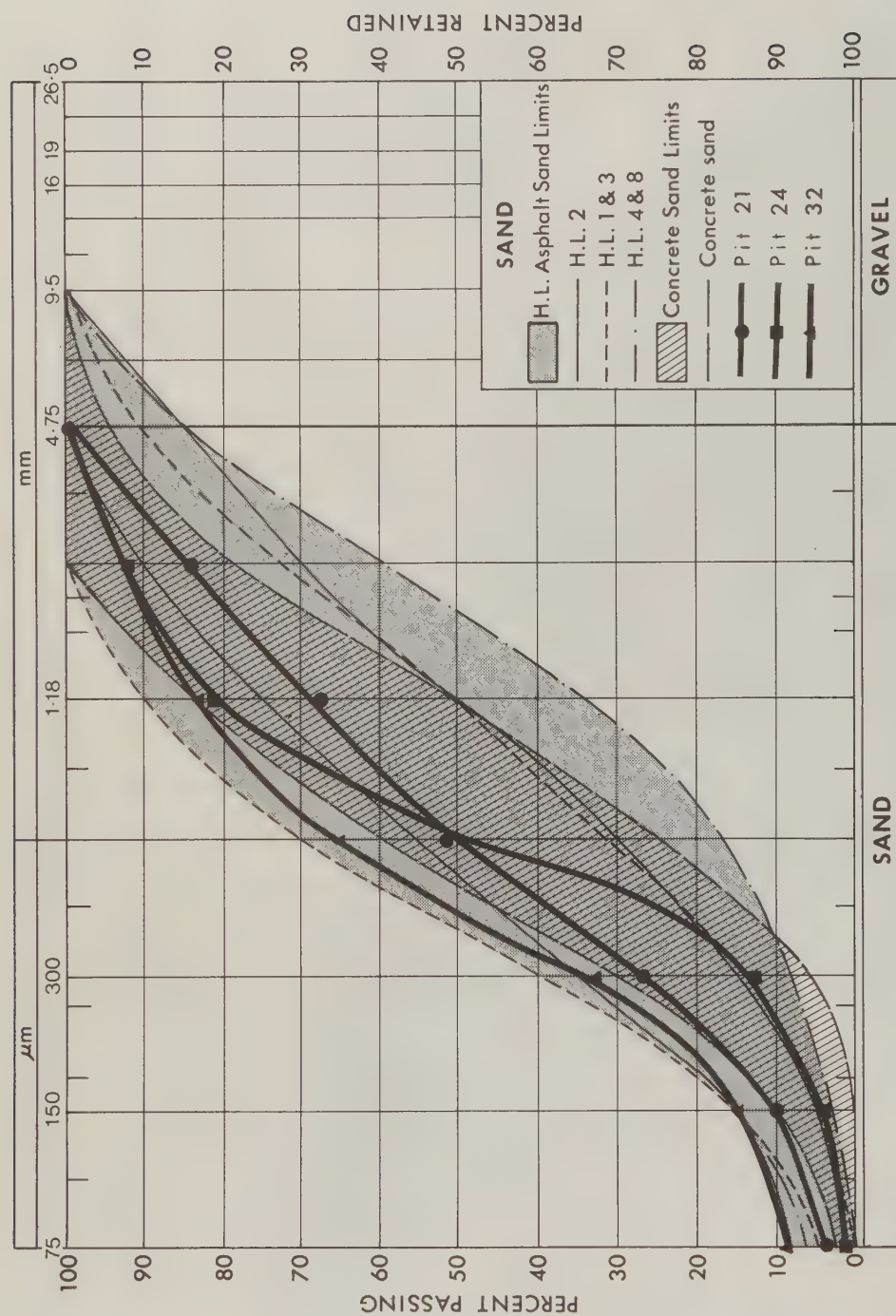


FIGURE 4b: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

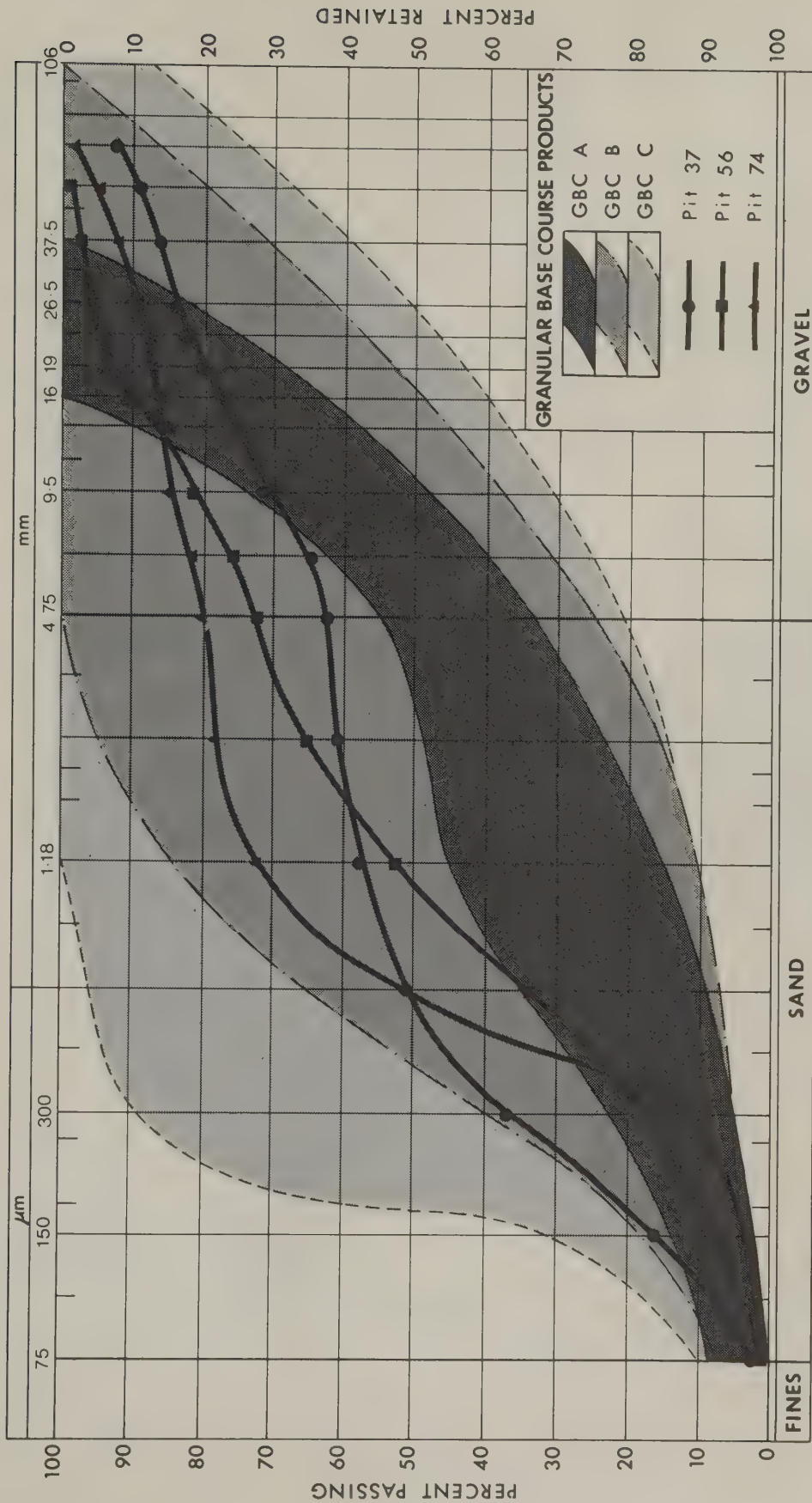


FIGURE 5a: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

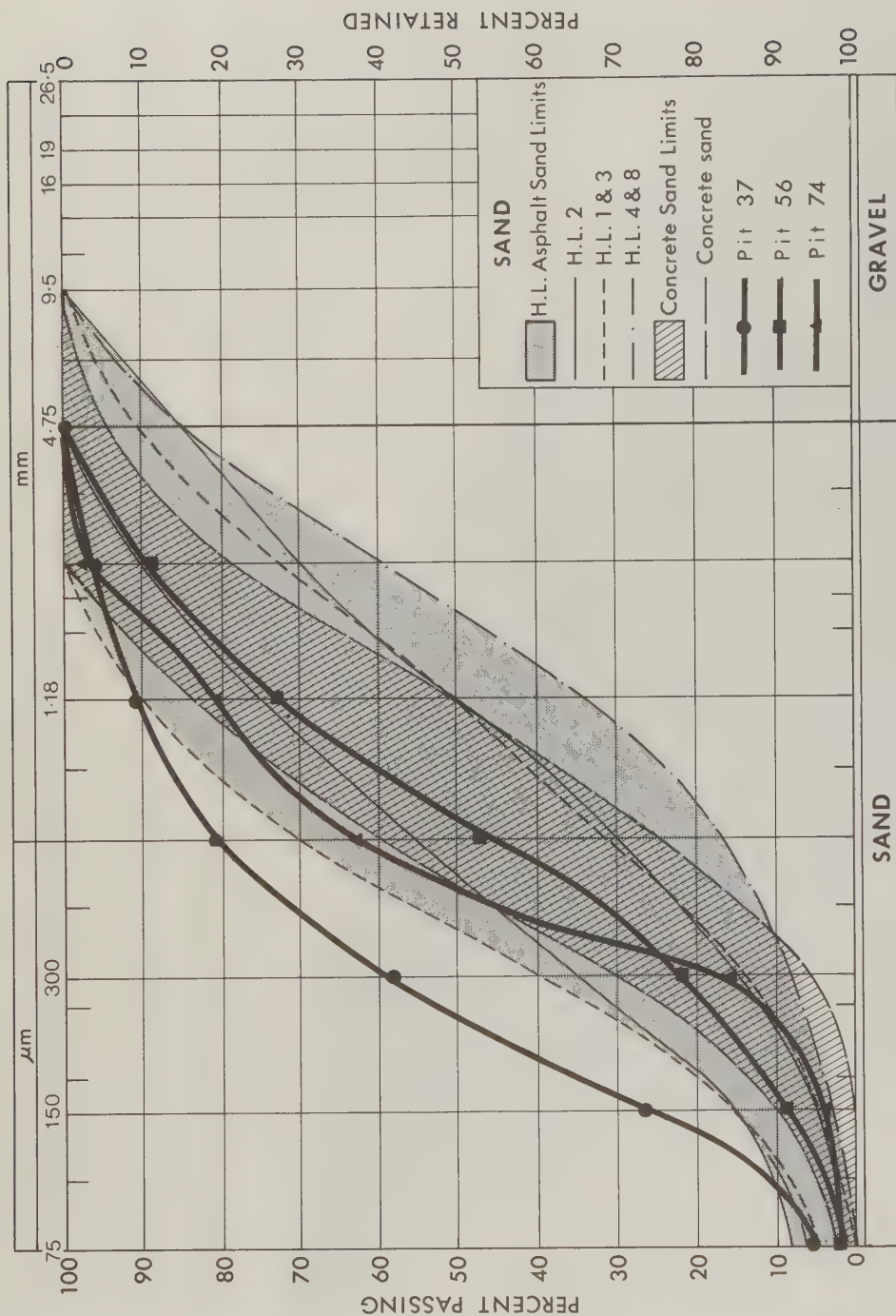


FIGURE 5b: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

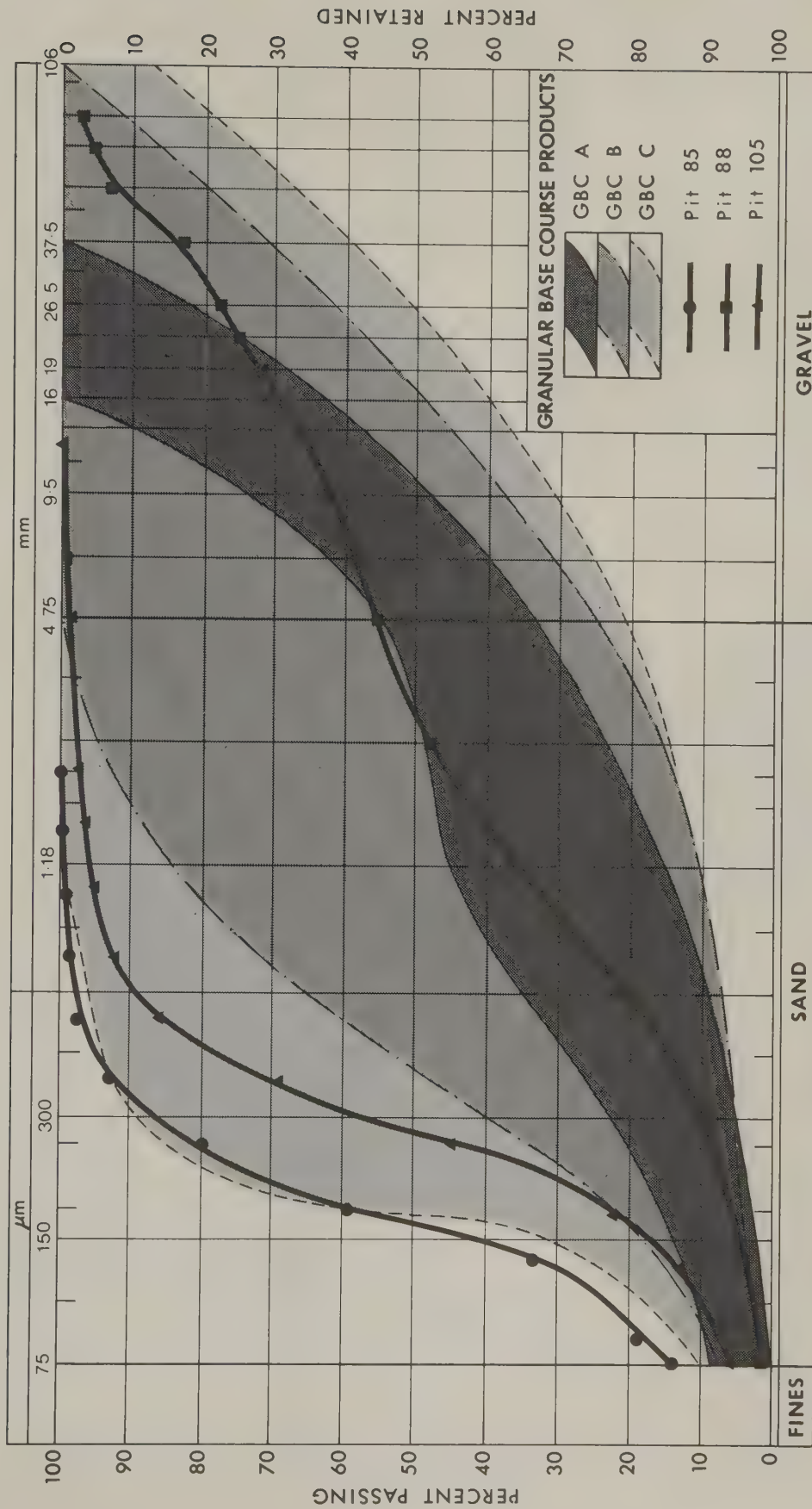


FIGURE 6a: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

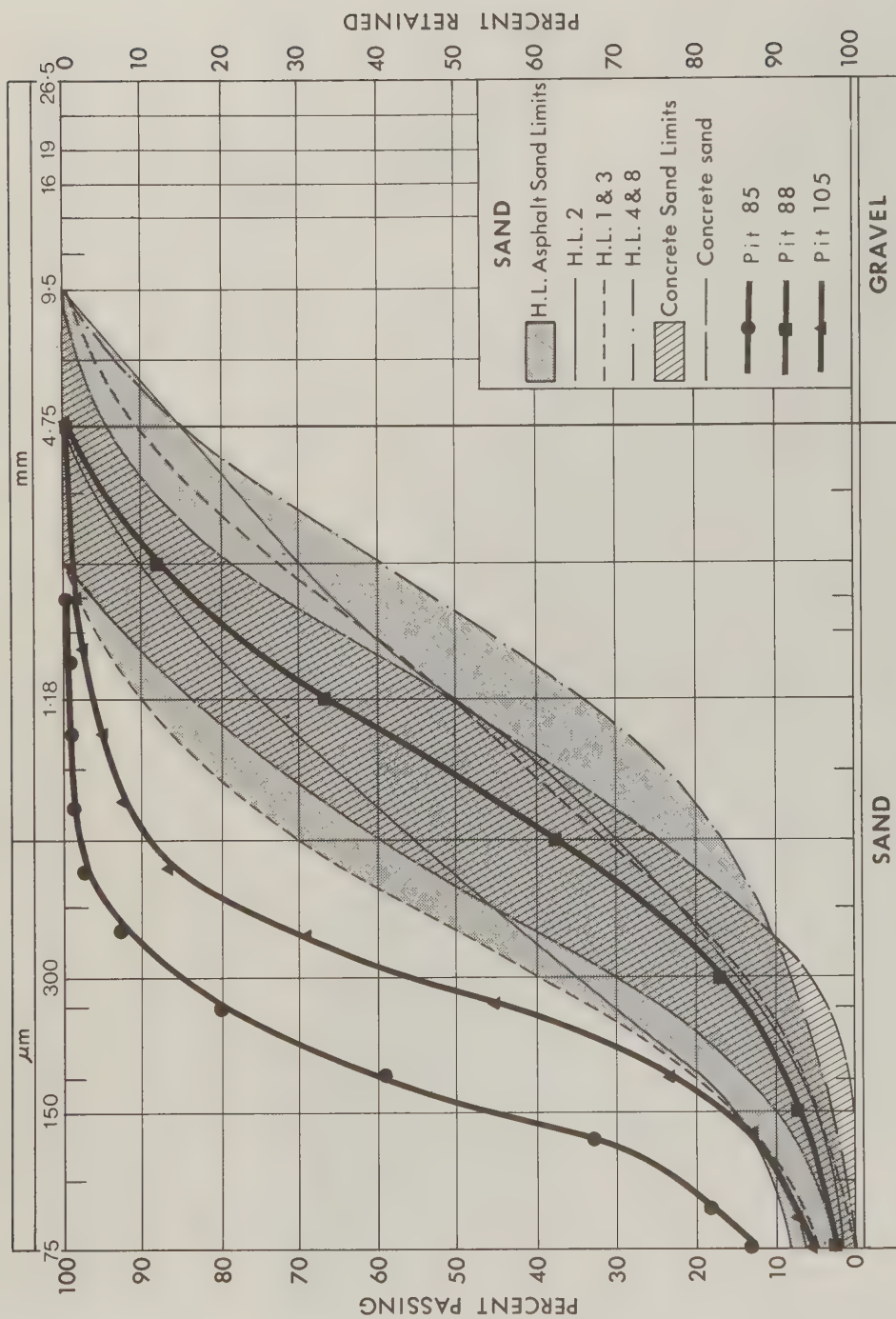


FIGURE 6b: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

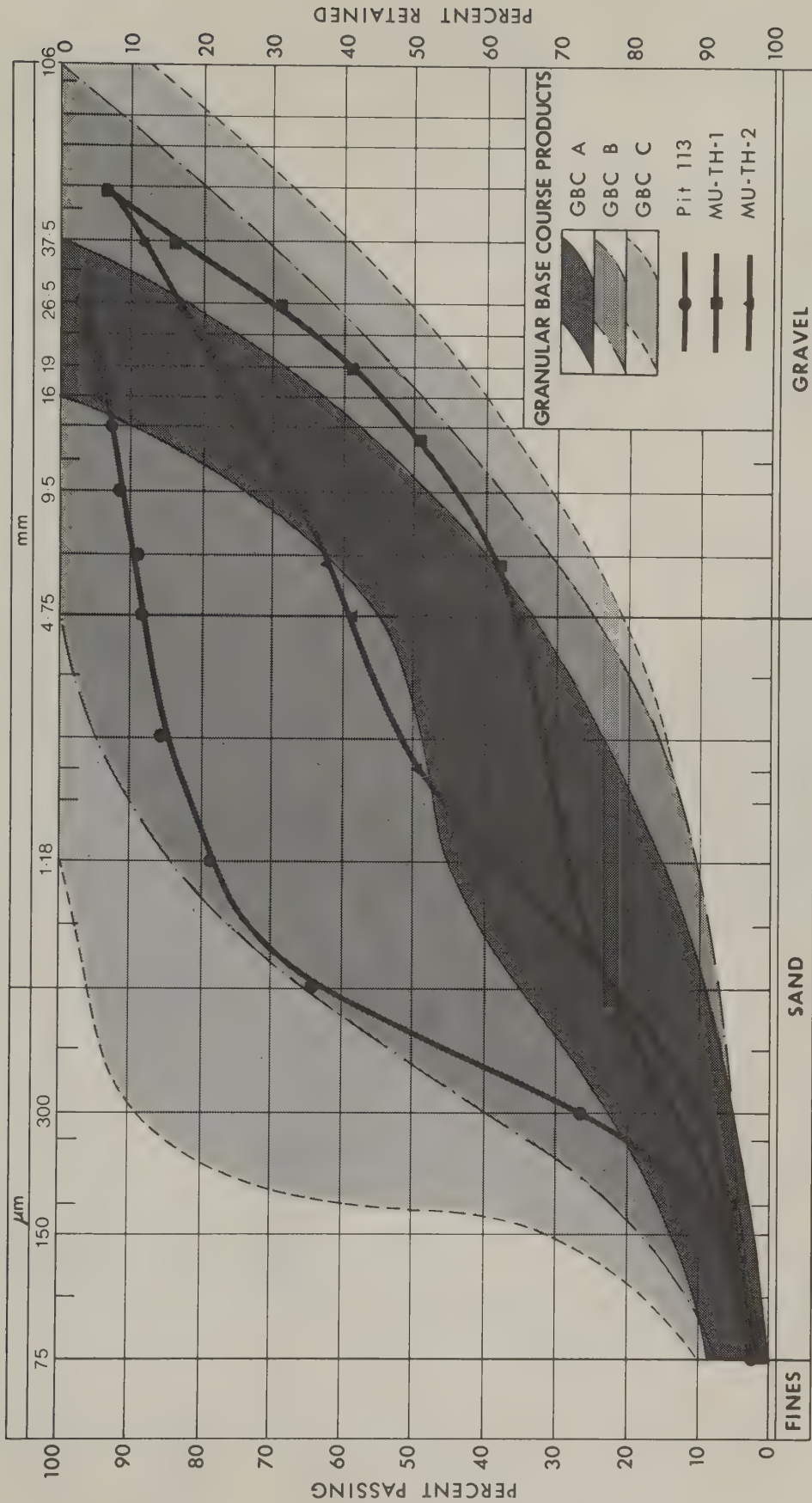


FIGURE 7a: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

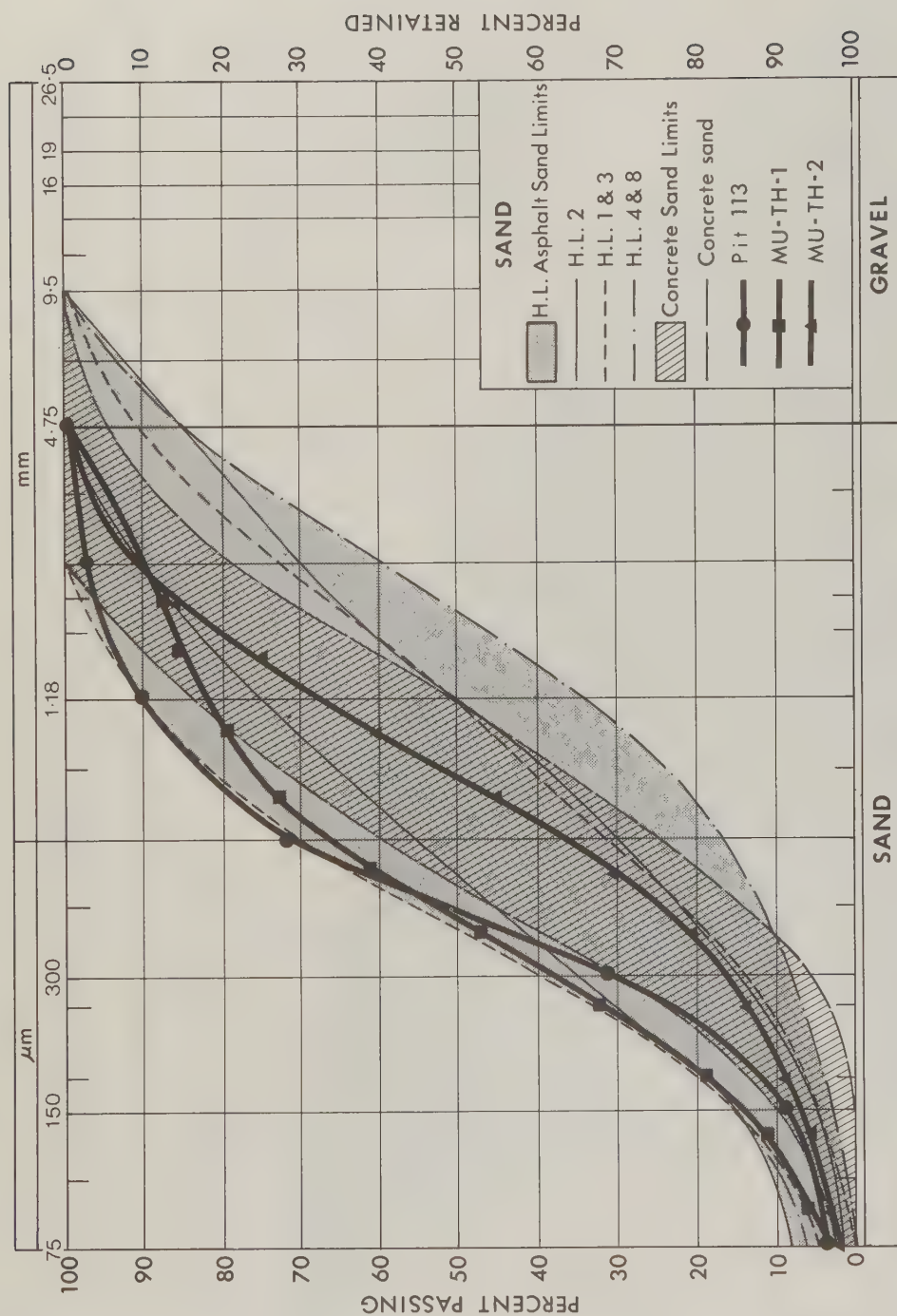


FIGURE 7b: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

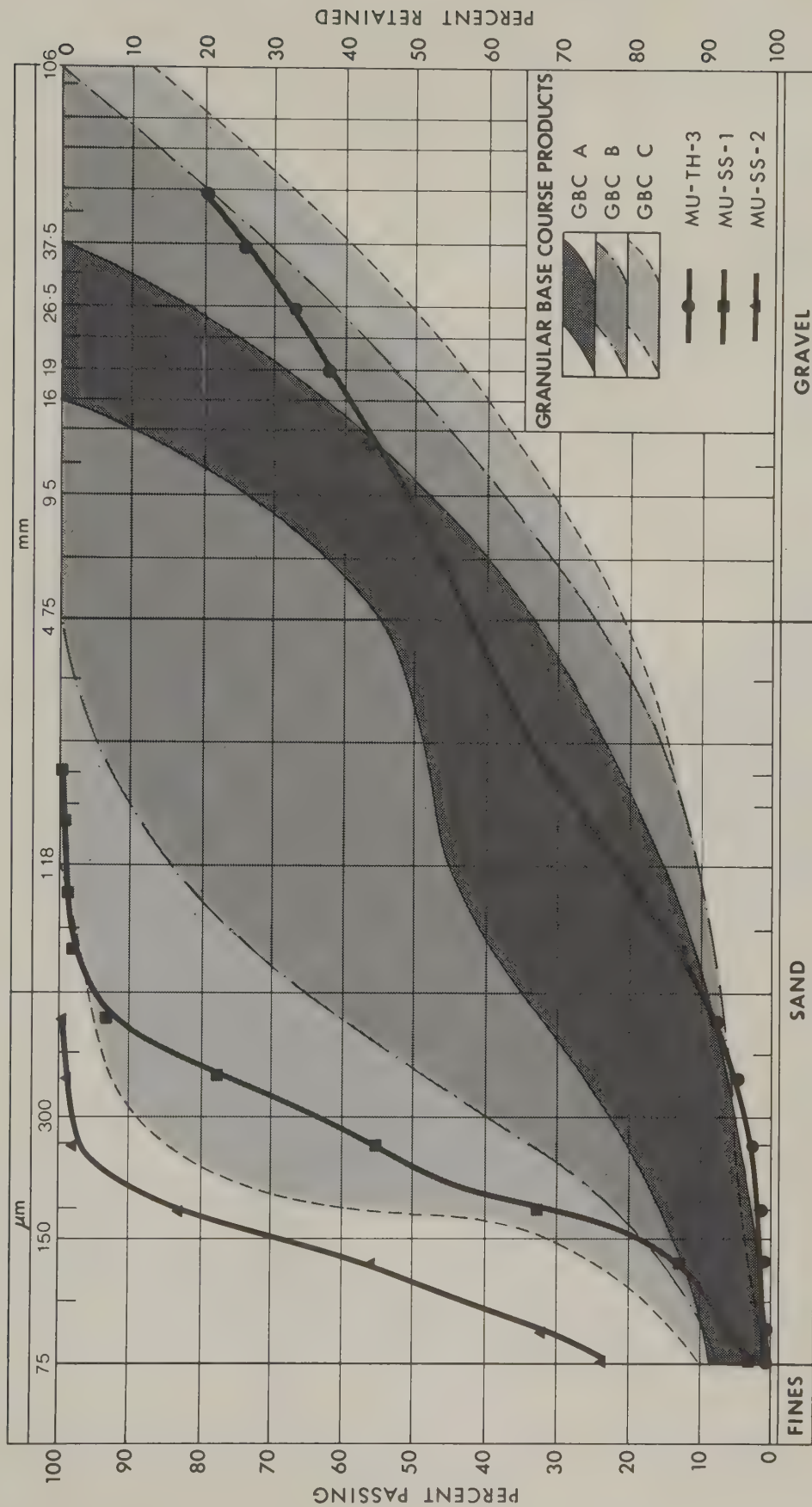


FIGURE 8a: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

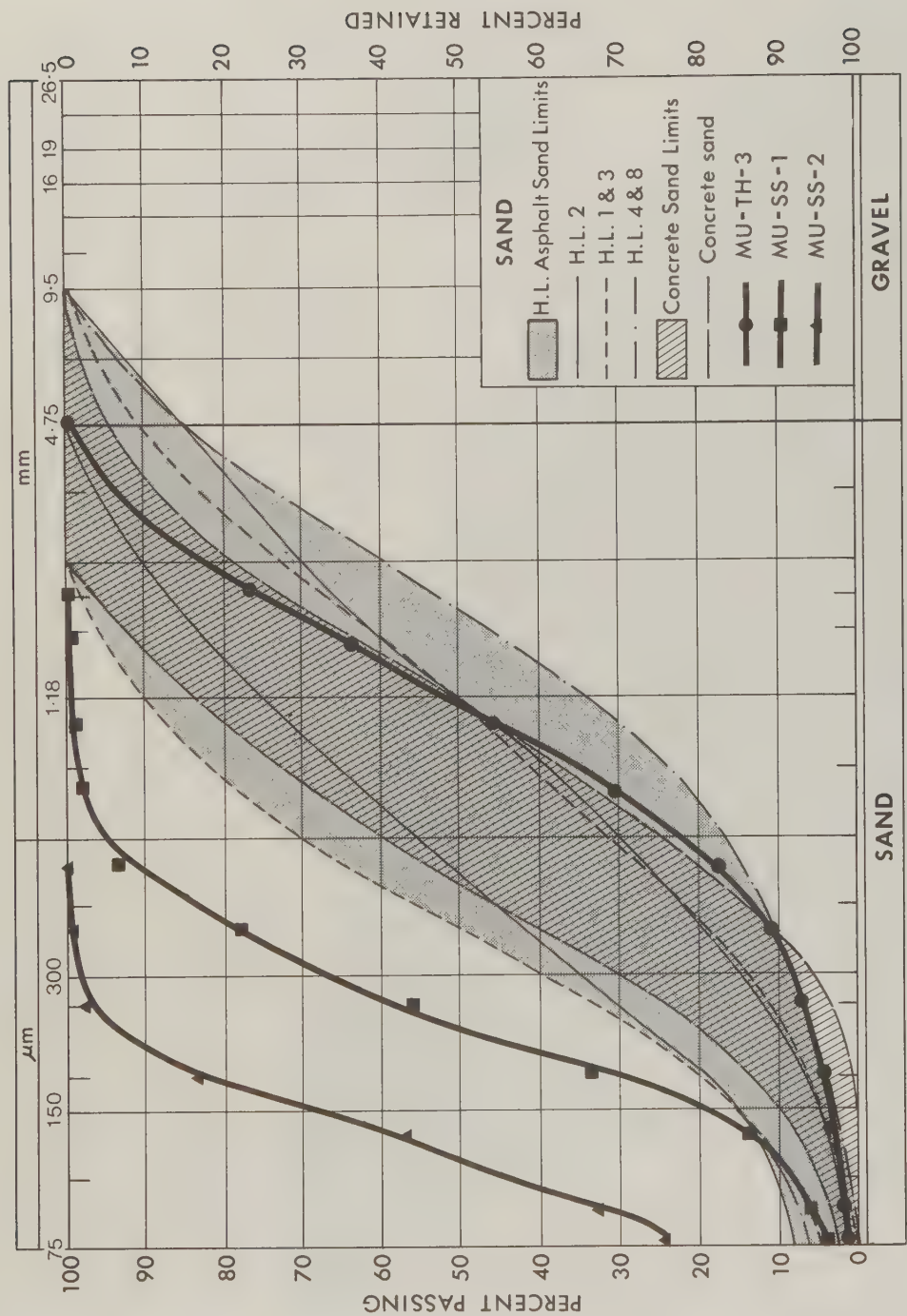


FIGURE 8b: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

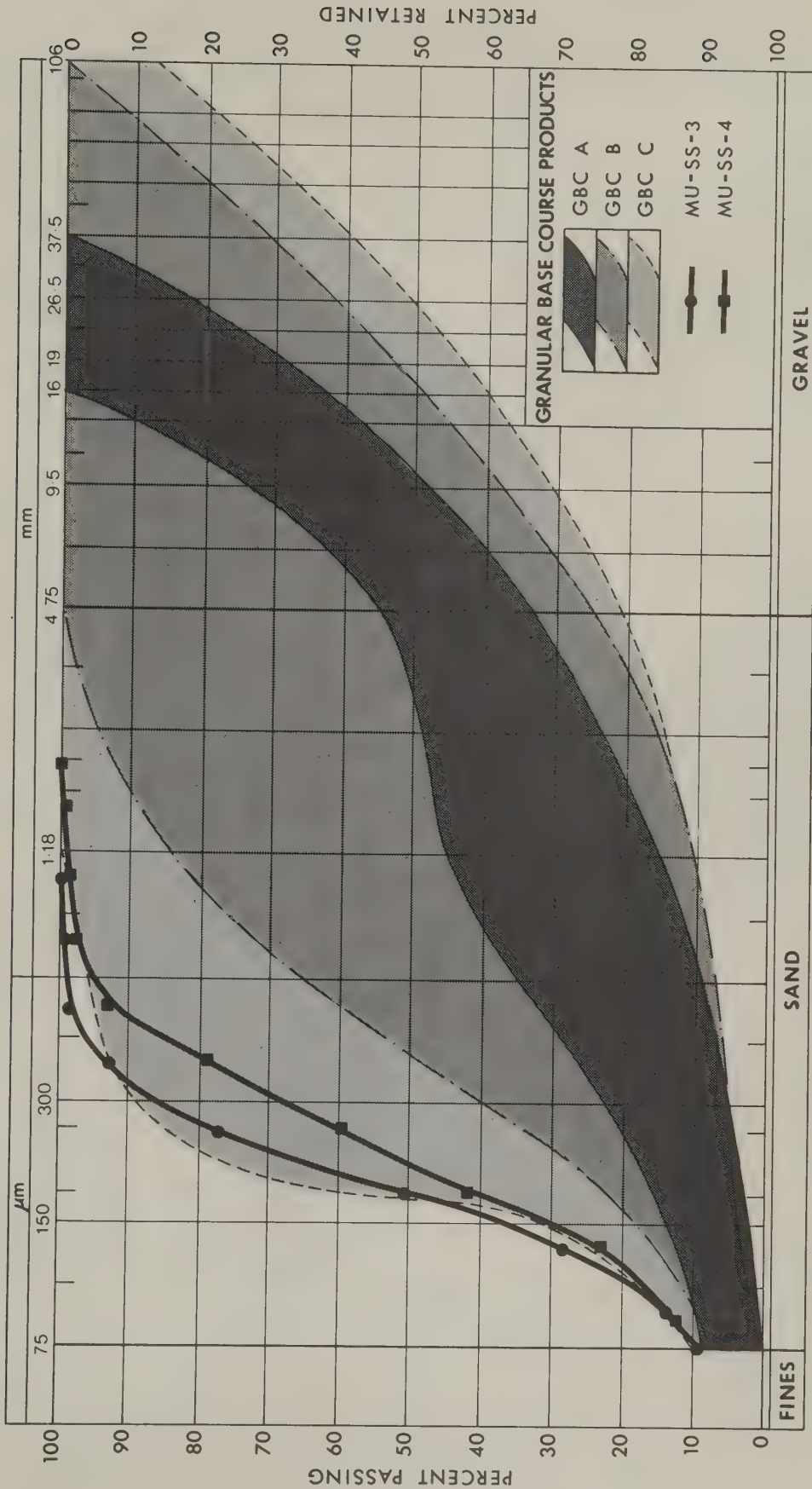


FIGURE 9a: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

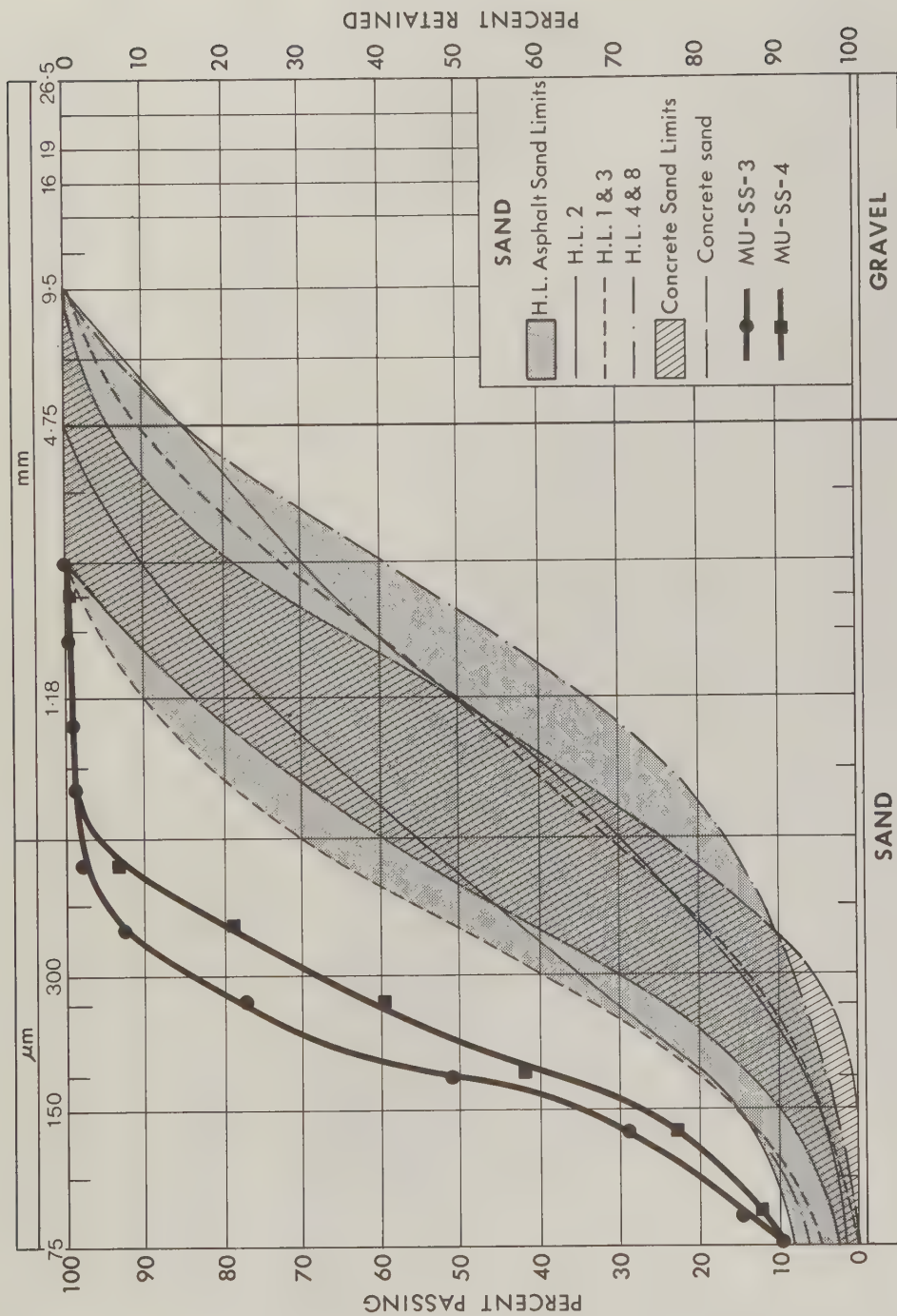


FIGURE 9b: AGGREGATE GRADING CURVES, TOWN OF BRACEBRIDGE

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

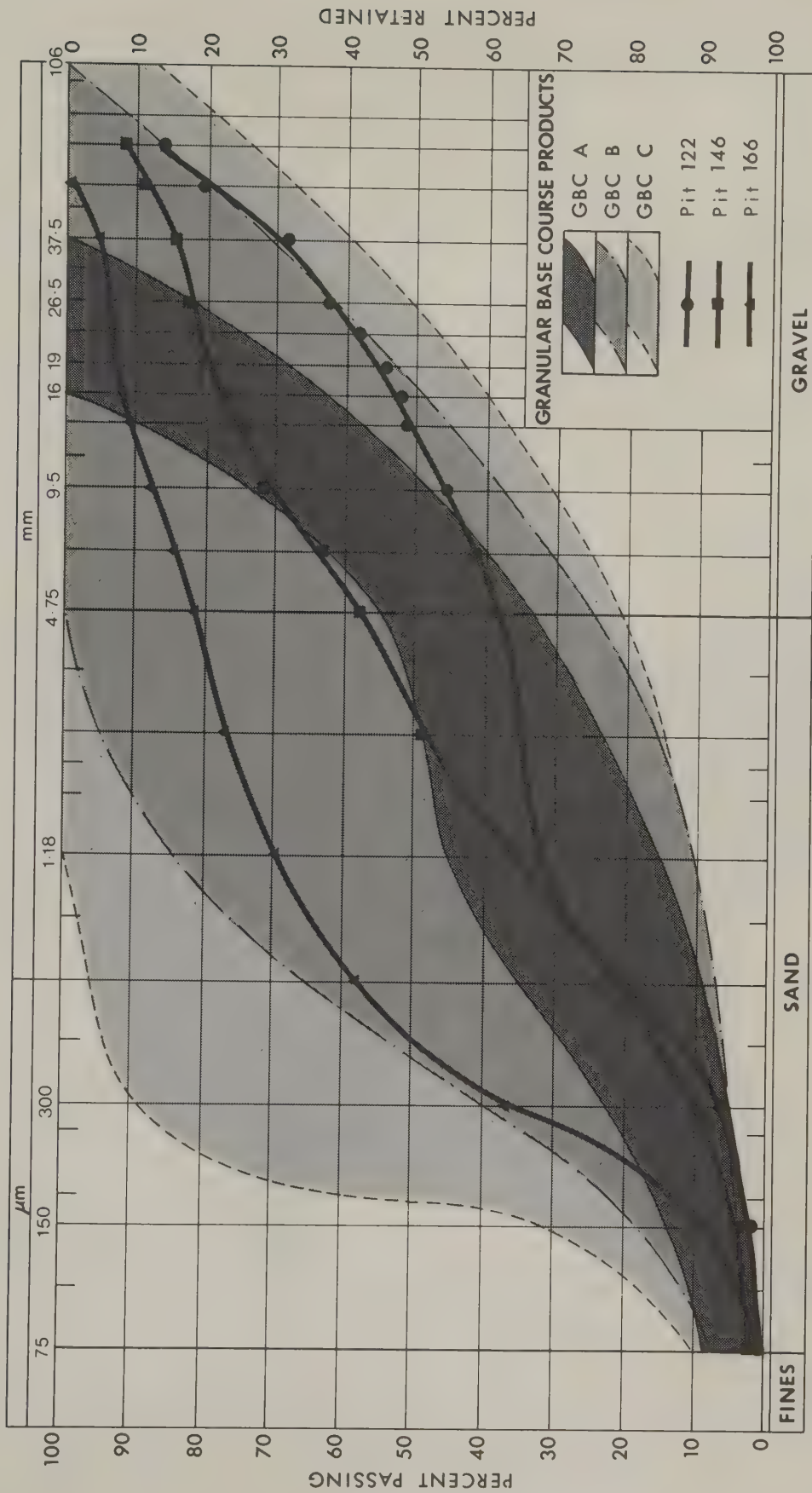


FIGURE 10a: AGGREGATE GRADING CURVES, TOWN OF GRAVENHURST

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

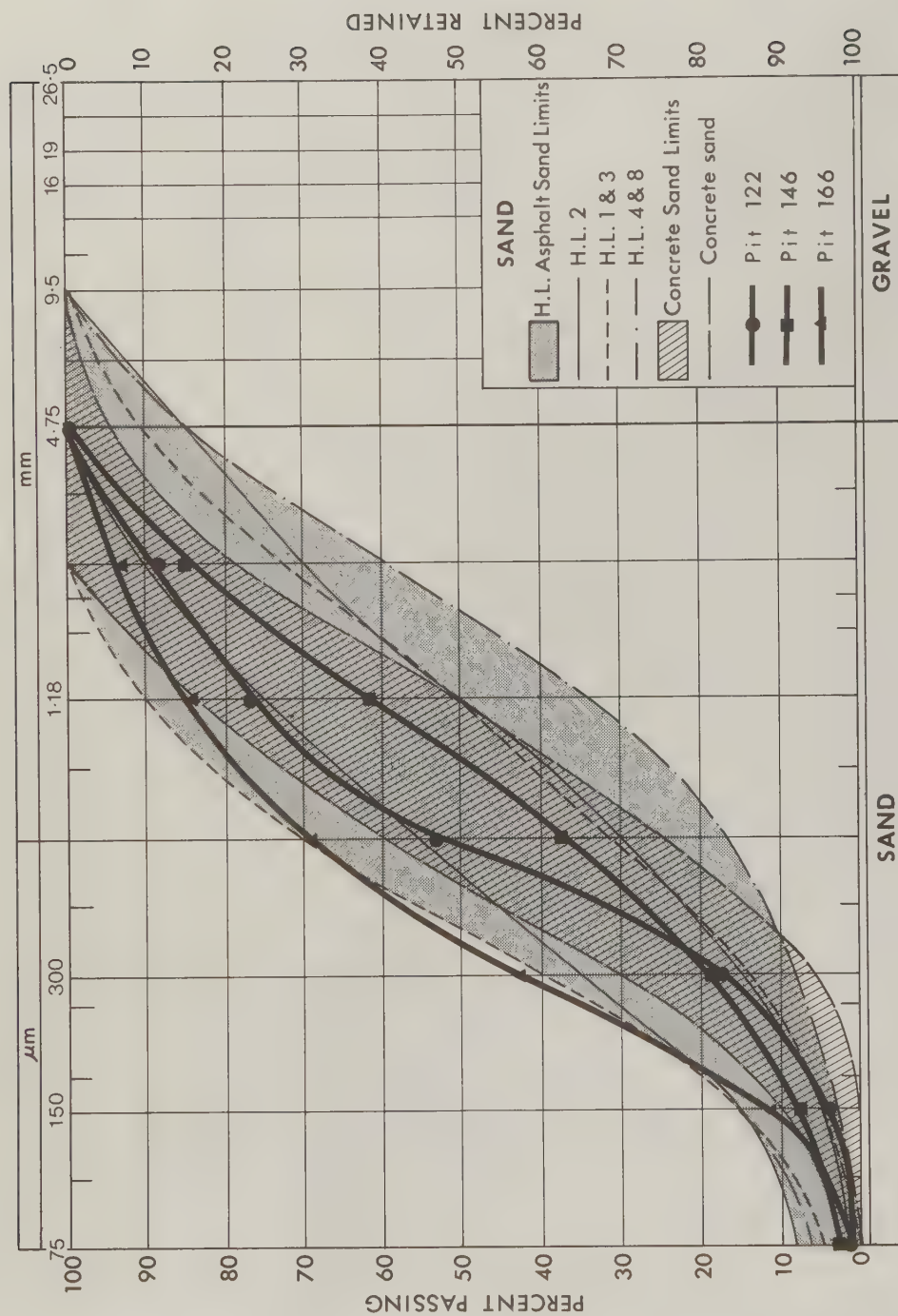


FIGURE 10b: AGGREGATE GRADING CURVES, TOWN OF GRAVENHURST

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

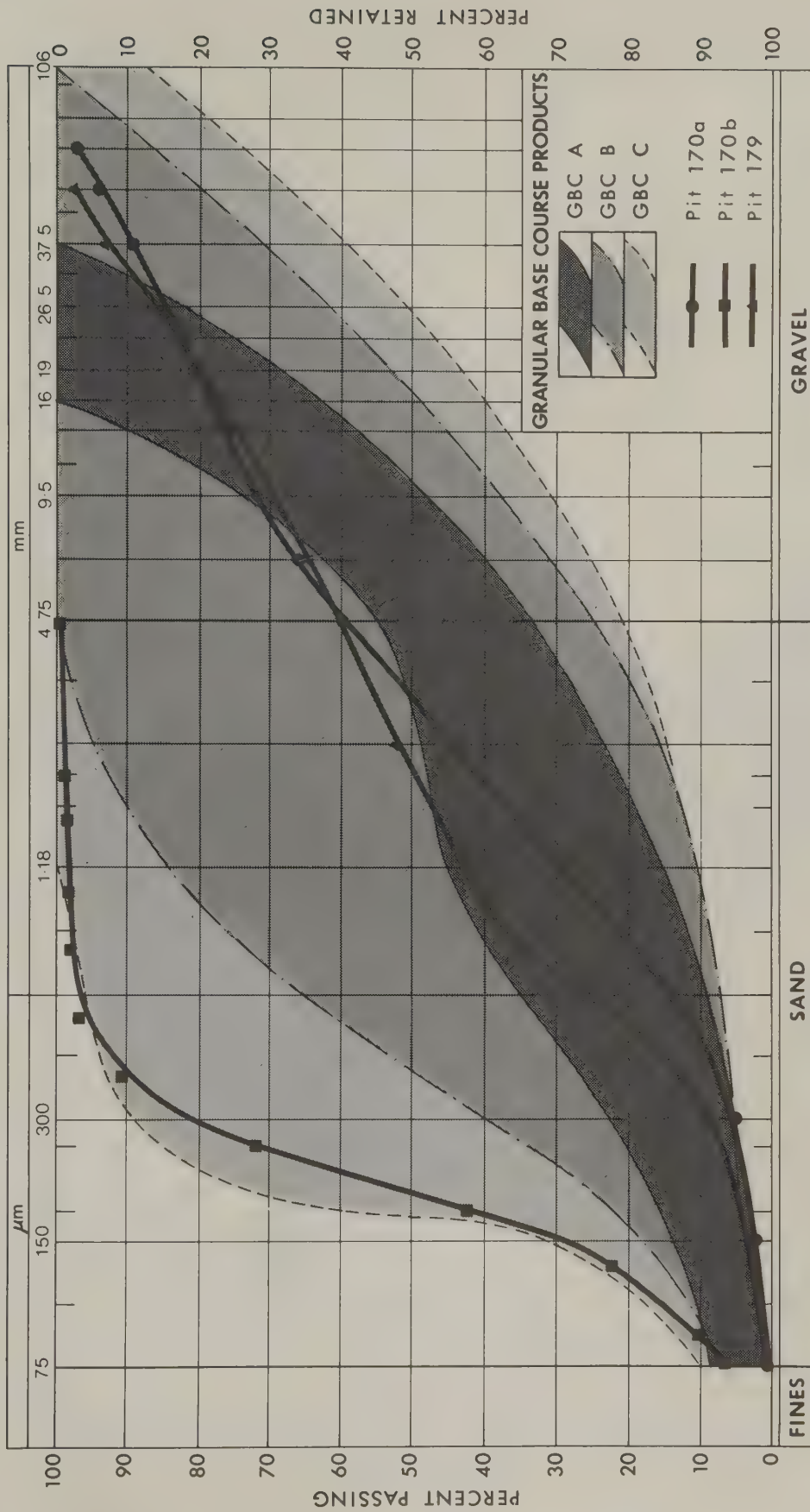


FIGURE 11a: AGGREGATE GRADING CURVES, TOWN OF GRAVENHURST

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

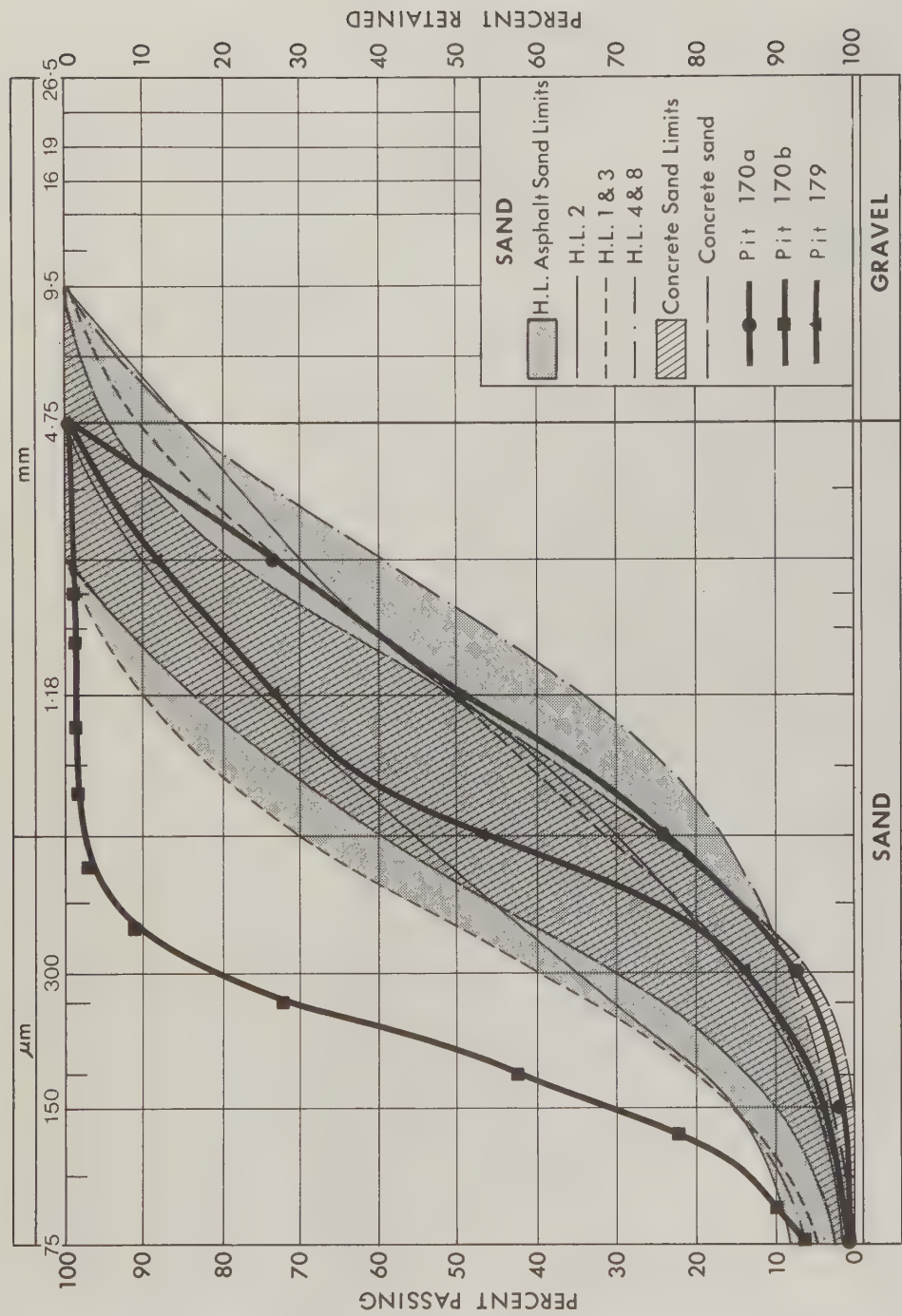


FIGURE 11b: AGGREGATE GRADING CURVES, TOWN OF GRAVENHURST

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

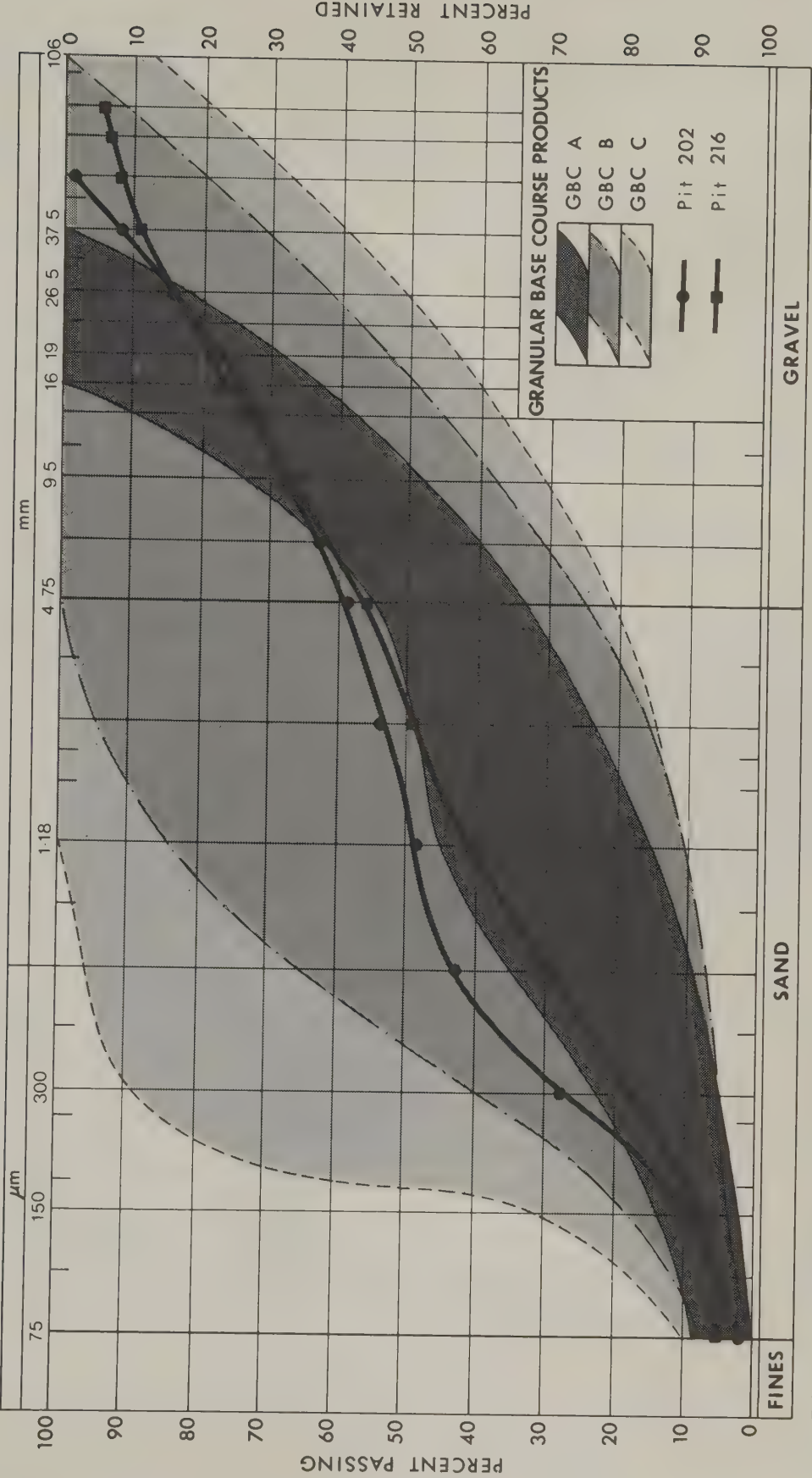


FIGURE 12a: AGGREGATE GRADING CURVES, TOWN OF GRAVENHURST

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

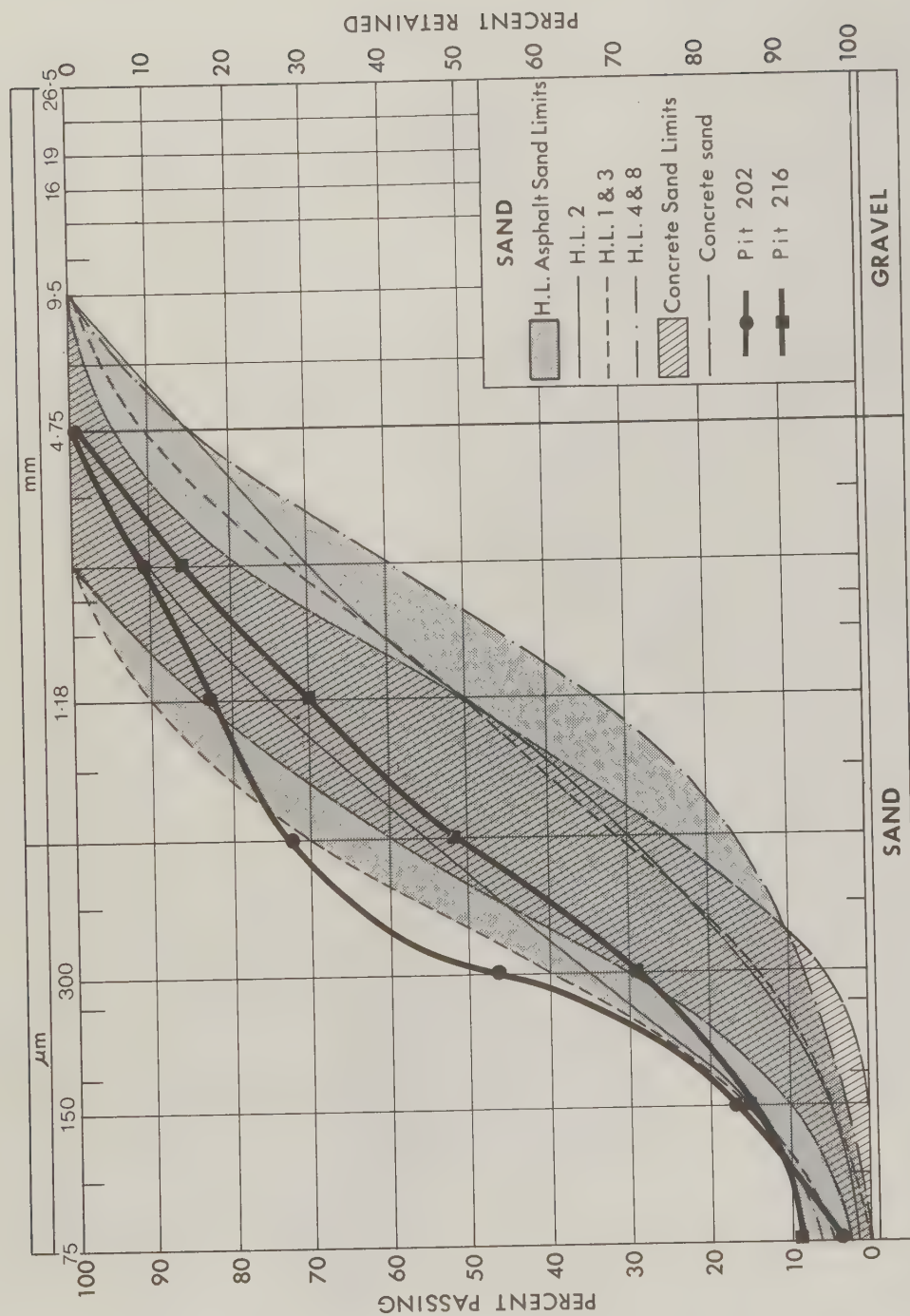


FIGURE 12b: AGGREGATE GRADING CURVES, TOWN OF GRAVENHURST

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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Appendix A — Suggested Additional Reading

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Appendix B — Glossary

ABRASION RESISTANCE: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

AGGREGATE ABRASION VALUE: This test directly measures the resistance of aggregate to abrasion with silica sand and a steel disk. The higher the value, the lower the resistance to abrasion. For high quality asphalt surface course uses, values of less than 6 are desirable.

ALKALI-AGGREGATE REACTION: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

BENEFICIATION: Beneficiation of aggregates is a process or combination of processes which improves the quality (physical properties) of a mineral aggregate and is not part of the normal processing for a particular use, such as routine crushing, screening, washing, or classification. Heavy media separation, jigging, or application of special crushers (e.g., “cage mill”) are usually considered processes of beneficiation.

BLENDING: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

BULK RELATIVE DENSITY: An aggregate with low relative density is lighter in weight than one with a high relative density. Low relative density aggregates (less than about 2.5) are often non-durable for many aggregate uses.

CAMBRIAN: The first period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago. The Cambrian precedes the Ordovician Period.

CLAST: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DRIFT: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as “dirt”, these particles are in the silt and clay size range.

GLACIAL LOBE: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in Ontario.

GNEISS: A coarse-textured metamorphic rock with the minerals arranged in parallel streaks or bands. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

GRADATION: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durabil-

ity, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANITE: A coarse-grained, light-coloured rock that ordinarily has an even texture and is composed of quartz, and feldspar with either mica, hornblende or both.

GRANULAR BASE COURSE: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (HL 1, 3 and 4), or as binder course (HL 2 and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY: The description of rocks on the basis of such characteristics as colour, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

LOS ANGELES ABRASION AND IMPACT TEST: This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported, and placed. Values less than about 35 percent indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45 percent indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

MAGNESIUM SULPHATE SOUNDNESS TEST: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test. Values greater than about 12 to 15 percent indi-

cate potential problems for concrete and asphalt coarse aggregate.

MELTWATER CHANNEL: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

PETROGRAPHIC EXAMINATION: An aggregate quality test based on known field performance of various rock types. In Ontario the test result is a Petrographic Number (PN). The higher the PN the lower the quality of the aggregate.

PLEISTOCENE: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POLISHED STONE VALUE: This test measures the frictional properties of aggregates after 6 hours of abrasion and polishing with an emery abrasive. The higher the PSV, the higher the frictional properties of the aggregate. Values less than 45 indicate marginal frictional properties, while values greater than 55 indicate excellent frictional properties.

POSSIBLE RESOURCE: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

PRECAMBRIAN: The earliest geological period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

SOUNDNESS: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C — Geology of Sand and Gravel Deposits

The type, distribution, and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT) These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K) Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and cross-bedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as “undifferentiated ice-contact stratified drift” (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E) Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers, consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain

size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC) This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW) Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier’s margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Subaqueous Fan (SF) Subaqueous fans are formed within or near the mouths of meltwater conduits when sediment-laden meltwaters are discharged into a standing body of water. The geometry of the resulting deposit is fan- or lobe-shaped. Several of these lobes may be joined together to form a larger, continuous sedimentary body. Internally, subaqueous fans consist of stratified sands and gravels which may exhibit wide variations in grain size distribution. As these features were deposited under glacial lake waters, silt and clay which settled out of these lakes may be associated in varying amounts with these deposits. The variability of the sediments and presence of fines are the main extractive problems associated with these deposits.

Alluvium (AL) Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain.

The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB) These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD) These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP) The nearly level surface marking the floor of an extinct glacial lake. The sedi-

ments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM) These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD) Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consist of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

Appendix D — Aggregate Quality Testing

Four types of aggregate quality tests have been performed on selected samples from the project area. A description and the specification limits for each test are included in this appendix. Although a specific sample meets or does not meet the specification limits for a certain product, it may or may not be acceptable for that use based on field performance. Additional quality tests other than the four major tests listed in this appendix can be used to determine the suitability of an aggregate. The above four types of tests were performed by the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation.

Absorption Capacity Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate. This test is conducted in conjunction with the determination of the sample's relative density.

Los Angeles Abrasion and Impact Test This test measures the resistance to abrasion and the impact strength of ag-

gregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported, and placed. Values less than about 35 percent indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45 percent indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

Magnesium Sulphate Soundness Test This test is designed to simulate the action of freezing and thawing on aggregate. Those aggregates which are susceptible will usually break down and give high losses in this test. Values greater than about 12 to 15 percent indicate potential problems for concrete and asphalt coarse aggregate.

Petrographic Examination Individual aggregate particles in a sample are divided into categories good, fair, poor, and deleterious, based on their rock type (petrography) and knowledge of past field performance. A petrographic number (PN) is calculated. The higher the PN, the lower the quality of the aggregate.

TABLE D1. SELECTED QUALITY REQUIREMENTS FOR MAJOR AGGREGATE PRODUCTS

TYPE OF MATERIAL	TYPE OF TEST				
	COARSE AGGREGATE				FINE AGGREGATE
	Petrographic Number Maximum	Magnesium Sulphate Soundness Maximum % Loss	Absorption Maximum %	Los Angeles Abrasion Maximum % Loss	Magnesium Sulphate Soundness Maximum % Loss
Granular Base A	200	—	—	60	—
16 mm Crushed Type 'A'	160	—	—	35	—
16 mm Crushed Type 'B'	200	—	—	60	—
Granular Subbase B	250	—	—	—	—
Granular Subbase C	250	—	—	—	—
Granular Subbase D	—	—	—	—	—
Hot Mix - HL 1	100	5	1.0	15	16
Hot Mix - HL 2	—	—	—	—	—
Hot Mix - HL 3	135	12	1.75	35	16
Hot Mix - HL 4	160	12	2.0	35	20
Hot Mix - HL 8	160	15	2.0	35	20
Structural Concrete and Concrete Base	140	12	2.0	35	16
Pavement Concrete and Exposed Structure Deck	125	12	2.0	35	16

(Ministry of Transportation Forms 1002, 1003 and 1010)

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